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ORIGINAL ARTICLES.

I.—The Kishon and Jordan Valleys.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

THAT broad trench through the Palestine Highlands, an ancient highway and battlefield of nations—the plain of Esdraelon or the valley of Megiddo, together with the plain of Acre—has for long presented to me a difficult problem in Physical Geology, for it seemed inexplicable by subaerial denudation under existing conditions. Its floor varies roughly from five to eight miles in breadth; running approximately from south-east to north-west, it is bounded on the more western side by the limestone mountains of Samaria and on the more eastern by those of Galilee. The former descend from the ridge of Carmel (1,742 feet at highest) with a fairly steep escarpment, which becomes a little less regular as we follow it to the bastion-mass of Mount Gilboa; the latter correspond in their general outlines with those of the eastern portion of Samaria, but the advance of a lower spur towards the south-west divides the plain of Esdraelon from that of Acre, by a kind of strait in which, so far as I could see, there is but little level ground on either side of the Kishon. This spur, however, of the northern hills, hardly does more than interrupt the floor of the Kishon valley, for above it the great trench is continued between two hill masses, much of these ranging from thirteen to sixteen hundred feet above sea-level. Beyond the strait the upper basin (plain of Esdraelon) quickly broadens out, extending towards the south-east for about fifteen or sixteen miles, where it is divided into two arms by Jebel Duhy (Little Hermon) (1,690 feet), which is thus isolated from Tabor (1,846 feet) on the north, and from Gilboa (1,698 feet) on the south; a broad, rather shallow, grassy valley descending from the last-named mass to lose itself in the plain. Neither it nor one or two other tributaries from the Galilee hills count for much, but the two arms maintain their trench-like form, cutting through the limestone isthmus which must once have united Samaria and Galilee. These are still, though much narrower than the plain of Esdraelon, disproportionately broad; their watersheds are low,

ill-marked, and lie farther west than the natural position. The gap between Duhy and Tabor is the narrower, and, so far as I can ascertain, a few feet the higher; that between the former and Gilboa is between two and three miles wide and about 270 feet above sea-level. One position in the 'strait' leading to the plain of Acre, according to the Palestine survey map, is 80 feet above sea-level, so the average down-slope of the plain of Esdraelon must be about four yards in a mile. A plain it is not, however, in such a strict sense of the word as the Cambridgeshire fenland; for the bases of the hills of Galilee on one side and of Samaria on the other shelve gently down with occasional slight undulations so as to fuse imperceptibly with the actually level ground near the river brink. All this low land is covered with a thick, rich brown earth, a broad fertile expanse of arable land and herbage, in striking contrast with the comparatively bare limestone masses on either side.

Obviously this is a river valley—a trench not less than a thousand feet deep cut through the limestone highlands of Palestine—but it is on much too large a scale to have been excavated by the present Kishon system. The difficulties increase when we examine the Jordan valley. That is another trough, seldom less and often more than four miles wide. Its bed, where reached by the southern of the two passes, must be at least 700 feet below sea-level,[1] so the drop from the watershed must be quite 950 feet. The Jordan has carved its present course through old lacustrine deposits, of which we need now only say that they were formed when an unbroken sheet of water extended from the divide between the Red and the Dead Seas to the northern end of Lake Huleh.[2] They extend into a recess between the roots of Little Hermon and Gilboa, where, about 350 feet above the river, is Beisan, the ancient Bethshean.

The depth of the Sea of Galilee is about 165 feet, and it may occupy a true rock basin, for the river, no great distance below its outlet, runs, according to Lynch,[3] over a rocky bed. The surface of the Dead Sea is about 1,292 feet below the Mediterranean, its greatest depth being 1,278 feet, and the watershed between it and the Red Sea, on which are outcrops of limestone, is 660 feet above the latter. As so much has been written on the Jordan valley,[4] it

[1] The Sea of Galilee is 682·5 feet below sea-level.

[2] The water in this ancient lake seems to have risen to about 1,398 feet above its present level, or some 98 feet above the sea; that would be, in round numbers, 90 feet above the present surface of Huleh.

[3] "Expedition to the Dead Sea and the Jordan," chs. viii and ix.

[4] The literature connected with this subject is extensive, but I may say that, until I formed the conclusion expressed in this paper, I consulted books to ascertain facts rather than opinions. I made great use of Professor Hull's Memoir in the "Survey of Western Palestine" (though venturing to differ in one or two matters from him). Valuable references to literature are to be found in Professor Suess' classic work "Das Antlitz der Erde," Professor Lartet's "Géologie de la Mer Morte," and Professor Gregory's "Great Rift Valley," ch. xiii. I may also mention Professor I. C. Russell's paper in this Magazine (1888, p. 338, etc.), and the one by Mr. Hudleston on the Central African Lakes in the present volume. I have also consulted papers by Dr. Diener and Dr. Blanckenhorn, though to one or two of their writings I have not had access.

will suffice to say (1) that all features which meet the eye are indicative of subaerial erosion; (2) that examination of its geological structure shows it to have been initiated and determined by a series of more or less parallel faults, which extend from somewhere south of the Taurus range to the junction of the Gulf of Akabah with the Red Sea, where they run up against another and still greater system; (3) that some geologists consider the depression, now partly occupied by the Dead Sea, and the elevation to the south of it, to be original features produced by unequal subsidence during the process of faulting, while others maintain that the Jordan once found its way southward through the Gulf of Akabah and that the present configuration of its bed is due to subsequent movements differing in direction from the original.

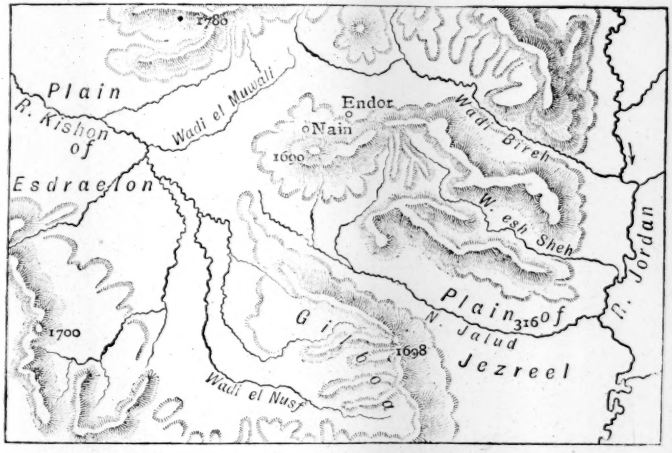

FIG. 1.—THE NEIGHBOURHOOD OF THE ESDRAELON GAP.

Before proceeding farther I venture to call attention to the misapplication (increasing, I think) of the term 'rift valley' to the Jordan. In the strict sense of the word 'rift' (according to good dictionaries of our language) such a valley must be, on any large scale, a great rarity. One would not, however, quarrel much with the application of the term (as by Professor Gregory in Masailand) to a valley where the surface of rupture, at least on one side, was still comparatively 'raw'—unmodified by denudation. That cannot be said of the Jordan, where the fault system can only be detected on examination. Every feature in the landscape speaks of ordinary meteoric agencies, so that the Lake of Gennesaret and the Dead Sea are no more suggestive of 'rifts' than the Lakes of Orta or of Geneva. The Jordan valley, to use the accurate phrase applied to it by Suess,[1] is part of a 'graben versenkung.' 'Rift' is not an accurate translation for 'graben'; 'trough' is far better, and as we speak of

[1] "Antlitz der Erde," vol. i, pp. 481, 482, etc. (See p. 373 et seq. of the newly published translation by Miss & Professor Sollas.)

a 'trough-fault,' why not a 'trough valley,' or, if we wish to be very precise, a 'trough-fault valley'? But a new word, especially if a little improper, seems to be as fascinating to some geologists as it is to children!

No one doubts that the physical features of Palestine have all been developed since the age of the Nummulitic Limestone; their broad outlines were probably determined, as we shall presently see, by the beginning of glacial times.[1] To excavate the broad 'Kishon valley' requires, in my opinion, not only a heavier rainfall, but also a much larger drainage area than now exists. It is obviously a 'beheaded' valley;[2] the two streams descending to the Jordan on either side of Jebel Duhy have trespassed westwards and pushed the watershed in that direction. In other words, I consider the Kishon valley to be older than that of the Jordan, and still to retain, west of the passes, its principal ancient features.[3] But where was the original watershed? If it were to the west—somewhere out in the Mediterranean—then Jebel Duhy must have been an island dividing the river into two channels; a thing possible, but the less probable hypothesis. The features described above appeared to me, when I visited the country, to demand a watershed well to the east of the line connecting Tabor with Gilboa over Duhy. The watershed may have disappeared in the trough-faulting which determined the Jordan valley; but I doubt, apart from other obvious difficulties, whether that would be far enough to the east, and am disposed to place it on the Syrian highlands nearer to that from which streams now descend westwards to the Jordan, because the lower part of the valley, the present Kishon, seems to me so deep, level, and flat that it could only have been made by a stream not much less important than that of the Jordan itself. I am unable to identify the old course of its upper waters with any existing valley; but that is not surprising, because the amount of subsidence in the Jordan trough has maintained, if it has not accelerated, denudation on its western flank,[4] while cutting off the supply has left the lower part of the ancient valley—the Esdraelon–Acre trench—very much as it was.[5] So I suppose the movement which first raised the Syrian highlands (including Palestine) above the sea culminated at an axis still indicated by the head waters of the Jarmuk, the Zerka, and many other streams,

[1] It is almost needless to observe that in this interval much work was done in 'making scenery' all round the Mediterranean border.

[2] My friend Professor J. W. Gregory emphasises this conclusion in his "Great Rift Valley" (pp. 253–255), but I may say that each of us reached it independently of the other, and we take opposite views as to which was the executioner. The sketch-map inserted above (Fig. 1), for which I am indebted to his kindness and that of his publisher, Mr. J. Murray, brings out very clearly the extent of the trespass.

[3] The outlet of the Orontes (Nahr-el-Asi), perhaps also of the Leontes (Nahr-el-Litany), may be contemporary features in the structure of Syria.

[4] To this, of course, I attribute the westward trespassing of the shorter streams on that side.

[5] To behead a valley, as we can see in the case of the Inn between St. Moritz and the Maloya, practically puts a stop to erosion in the uppermost basin.

which formerly made their ways (the final outlets not being numerous) westwards to the Mediterranean.

We come next to the great trough-valley. So much has been written about this, which includes the whole course of the Jordan and the major part of both the Leontes and the Orontes, that I need not enter into minute details. Dr. Blanckenhorn's section across southern Palestine[1] makes the general structure perfectly clear. The high upland west of the Jordan is formed by a flattened anticline, the eastern arm of which is dropped down by three parallel faults, the outermost practically forming the west side of that valley. A single but greater downthrow does the same on the opposite or eastern side, so the higher strata on both sides of the river are nearly on a level. The western flexure is prolonged, exaggerated, and complicated in the Lebanon range; the eastern in that of Anti-Lebanons, which I suppose to have been the earlier of the two.[2] Was the watershed between the Gulf of Akabah and the Dead Sea, with the formation of the latter and the peculiar depression of the major part of the Jordan valley, mainly determined by unequal subsidence of the faulted down trough-blocks, or was this valley, after its first definition, excavated down to the live rock which, though now generally invisible, must form its true floor, and subsequently traversed by flexures, due to forces acting nearly at right angles to the former set, which produced the general depression at the northern end and the marked barrier near the southern? Most authorities adopt the former view. They consider that the limestone, which crops out in ridges near this barrier in the bed of the trough, and the fact that the glens north of it trend towards the Dead Sea and south of it to the Gulf of Akabah, indicate the Arabah–Akabah watershed to have existed from the first. But travellers describe the valley bed as if (apart from the lacustrine deposits) it agreed very closely with the Ghor itself. But we should expect that, if these ridges were the remnants of an ordinary watershed, the united streams from each side of it would have carved in the floor of the trough a pair of narrow 'wadies' running in opposite directions: in other words, that we should find here a closer resemblance to the valley of the Jordan north of Lake Huleh. As a considerable amount of denudation must have taken place while the Jordan Lake was filling, and must have been continued while it was shrinking (for I suppose the cutting of terminal ravines such as those of the Kedron and the Kelt to be distinctly late features),[3] I am not surprised at the general directions of the larger valleys.

[1] Through Bethlehem; see Zeitschr. d. Deutsch. Palest. Vereins, xix (1898), pp. 1–59.

[2] To compare smaller with larger mountains, the structure here seems generally similar to that of Switzerland from the French frontier to the watershed between the Rhine and the Inn.

[3] In fact, more than one feature which I observed during my short visit to Palestine suggested that in the uplands denudation was proceeding very slowly, but became much more rapid in the vicinity of the Jordan.

But the study of its fauna and flora has much strengthened the arguments for the former connection of the Jordan valley with the Gulf of Akabah. In Canon Tristram's words,[1] written twenty years ago (which, as we can see from the excellent summary given by Professor Gregory,[2] have been fortified by additional evidence), "A review of the botany as well as the zoology of the Dead Sea basin reveals to us the interesting fact that we find in this isolated spot . . . . a series of forms of life, differing decidedly from the species of the surrounding region, to which they never extend, and bearing a strong affinity to the Ethiopian region, with a trace of Indian admixture. As the species which serve as the most striking illustrations of this fact live either in or beside fresh water, a river connection is the most natural agency by which to account for it, and as these species are absent from the Lower Nile valley and from Egypt, the river connection must have been established along the eastern side of the range of highlands which separates the Nile from the Red Sea." Professor Gregory, though advocating this connection, thinks it unnecessary to assume that "a river flowed the whole way from the Jordan to the northern end of the Red Sea," because fish from the south might have made their way to a lake, which is shown by its deposits[3] to have existed on the northern side of the watershed and a few feet below it, when "an occasional flood or a slight earth-movement would have enabled them to enter the stream which flowed northwards." That, no doubt, is possible, though I should think not very probable, unless the spawn were conveyed by birds, but it does not account for the continuous trench of the Arabah–Akabah valley. Professor Hull is not unconscious of this difficulty, for he says, speaking of the valley of the Arabah and this watershed,[4] "it is difficult to see how this great valley, which is sometimes seven or eight miles in width, especially near its centre,[5] could have been excavated and levelled down unless the action of the rivers and streams of the bordering hills had been originally supplemented by the levelling action of the sea waves on the south and the inland waters of a great lake on the north of the watershed." But so far as I am aware, there is no proof that the old Jordan valley lake ever rose more than about a hundred feet above the Mediterranean, and if the sea waves were to approach near to this barrier, to cut a fjord from forty to forty-five miles long, north of the present shore at Akabah, either the sea must have been more than 600 feet higher or the land the same amount lower than at present. In the former case I think that the Mediterranean would probably have occupied the valley of Esdraelon and gained access to the inland lake on one or both sides of Jebel

[1] "The Fauna and Flora of Palestine" (1884), p. xvi.
[2] "The Great Rift Valley" (1896), p. 262.
[3] They were discovered by Professor Hull.
[4] Mount Seir (1855), p. 82.
[5] In the "Survey of Western Palestine" (Geology), p. 18, he says that north of the watershed it is nearly double (6 or 7 miles).

Duhy; in the latter some sort of upheaval is admitted. Prof. Lartet, in his excellent memoir, objects to a differential uplift in the bed of the Jordan valley on the ground that there is no disturbance of horizontality in the strata exposed in its flanks. But we must remember that as the beds on both sides dip (on the west rather strongly) towards the valley, a slope at right angles, or in its direction, would be masked, especially as this would be small.[1] But according to Professor Lartet's map the strata do dip in the required direction. Both he and Professor Hull represent Nubian sandstone cropping out beneath the Cretaceous limestone very near the Arabah–Akabah watershed. The former runs downwards to the south end of the Dead Sea, and can be traced beneath the great masses of limestone forming the Moab Hills, until it disappears opposite to Jebel Kuruntil.[2] After a time, according to Professor Hull's map, it again crops out, being seen for the last time nearly due east of Shechem. Thus there must be a considerable bending or displacement parallel with the east and west fault running from near Bethlehem to the Dead Sea. True, this only accounts for about one-third of the amount which the flexure hypothesis requires, but the beds may have been already somewhat bent down when the trough-faulting began. This hypothesis obviously implies that the whole region from the Arabah to the sources of the Jordan has been considerably depressed. The latter, so far as I can ascertain, range from about three to rather over seven hundred feet above sea-level, which would be too low if the drainage had ever reached the Gulf of Akabah. But this and the 'sag' necessary (as indicated above) to form the Sea of Galilee (in an east and west line with which are the plateau of Asochis and the Bay of Acre; also the marked escarpment in the hills west of Safed) all suggest a system of faults and flexures almost at right angles to, and so probably not coeval with, the north and south system defining the Jordan valley. All geologists agree that before the end of the Pliocene period, "the existing land surfaces on either side of the Jordan–Arabah valley were in a condition not very different from that of the present day, at least in their main features." Professor Hull, from whom these words are quoted,[3] says "at the close of the Miocene epoch," but I am doubtful whether we can adopt this limit. If, as is very possible, the two greater systems of disturbances, which certainly affected a large part of the Mediterranean area, extended thus far east, the first uplift would occur at the close of the Eocene and the consequent sculpture during the Miocene period; the formation of the Jordan trough would belong to the second, or immediately post-Miocene movements, by which large parts of the western half of the Alps were so profoundly affected; and its sculpture would proceed during the Pliocene, the flexure of the trough occurring rather

[1] Taking the watershed as 700 feet above, and the Dead Sea as 1,300 feet below, sea-level, we get in round numbers a drop of 2,000 feet in about 70 miles, or on a rough average 1 in 175—less than a degree.

[2] The Mount of Temptation, the supposed scene of the Forty Days' Fast, conspicuous from and to north-west of Jericho.

[3] "Survey of Western Palestine" (Geology), p. 112.

later in this period.[1] That it was complete before the Glacial Epoch began is generally admitted. Dr. Blanckenhorn,[2] adopting the three epochs of ice-extension recognised in Germany, gives this arrangement of the later history of the Jordan valley :—

(1) First ice-age (rain epoch) : greatest height of the Jordan valley lake.

(2) First interglacial (dry epoch) : probable sinking of lake to about 328 feet above present level, when the salt of Jebel Usdum was precipitated.

(3) Second ice-age : rise of lake and formation of the high terraces.

(4) Second interglacial : probably the age of the volcanic outbreaks,[3] so conspicuous in the northern part of the valley (also the cutting of the Ghor).

(5) Third ice-age : formation of the lower terraces.

This chronological scheme is rather hypothetical, but it deserves careful consideration. I think, however, I am right in claiming the Esdraelon valley as a fragment of a system older than the Jordan, and pronouncing that river guilty of removing its neighbour's landmark westward. Such a removal is almost inevitable, because the descent of its tributaries on the right bank is so much more rapid than the slope of the Kishon valley.

II.—On a new Crocodilian Genus (*Notochampsa*) from the Upper Stormberg Beds of South Africa.

By R. Broom, M.D., Victoria Coll., Stellenbosch.

MR. A. L. DU TOIT, of the Cape Geological Commission, who has been for some months engaged in studying the Stormberg beds in the eastern part of the Colony, has been fortunate in making a number of discoveries of very great interest to the palæontologist. Among Vertebrates his most important finds have been the remains of two small crocodiles.

The first specimen, which was discovered by Mr. A. Isted in the Cave Sandstone at Funnystone, Barkly East, consists of the impressions of the under sides of most of the upper bones of the skull and of most of the dorsal armour. There are also preserved the remains of a scapula, a humerus, a radius and ulna, a femur, and a number of ribs. A restoration of the skull is shown in Fig. 1. When complete it probably measured 130 mm. in length, and the length of the whole crocodile was probably about 600 mm. Though the skull is too imperfectly preserved to show what are the relations to the already known families, enough is preserved to show that the crocodile belongs to the suborder Amphicœlia of Owen (= *Mesosuchia*, Huxley). The skull is characterised by the very large size

[1] One is reminded of the east and west flexures of later Pliocene age in the southern part of England.

[2] "Entstehung und Gesichte des Todten Meeres": Zeitsch. d. Deutsch. Palest. Vereins, xix (1896), pp. 1–64.

[3] There is nothing left to give a precise date to this period, during which, according to Dr. Blanckenhorn, prehistoric man appeared. It is supposed to be contemporaneous with that of the German loess.

of the squamosal bones, by the moderate size of the supra-temporal openings, by the nasals taking little part in the formation of the snout, and by each maxillary having only a few large teeth—probably 6 or 8.

I propose to call the form *Notochampsa Istedana*.

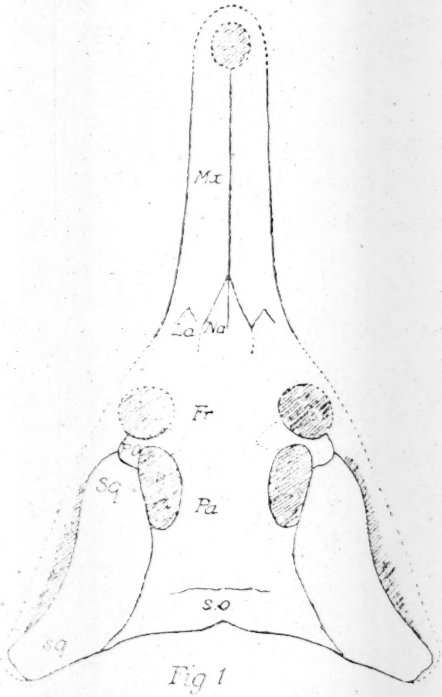

Fig 1

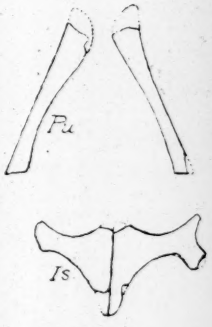

Fig 2

Fig 3

Fig 4

Fig. 1.—Restoration of skull of *Notochampsa Istedana*. × $\frac{2}{3}$. *Fr.* frontal; *La.* lachrymal; *Mx.* maxilla; *Na.* nasal; *Pa.* parietal; *P.O.* post-orbital; *S.O.* supra-occipital; *Sq.* squamosal.

Fig. 2.—Pelvic bones of *Notochampsa longipes*. × $\frac{1}{4}$. *Is.* ischium; *Pu.* pubis.

Fig. 3.—Twelfth dorsal scute of *Notochampsa Istedana*. × $\frac{1}{4}$.

Fig. 4.—Dorsal scute of *N. longipes*. × $\frac{1}{4}$.

The second specimen was found by Mr. Du Toit near the top of the Red beds at Kraai River, Eagles Crag, Barkly East. Though less is preserved than in the other specimen, the state of preservation is much better. The following bones have been displayed:—the almost perfect pubes and ischia, an imperfect ilium, the almost perfect right hind-limb, including the foot, the imperfect left hind-limb, the imperfect right fore-limb, portions of the dorsal and ventral armour, and a few imperfect vertebræ. A comparison of the dorsal plates with those of *Notochampsa Istedana* shows that the specimen from the Red beds belongs to a different species, though probably the same genus. The pelvis is typically Crocodilian in

that the pubis does not enter the acetabulum. The ilium is of small size. The limb bones are unusually long and slender. There are only four digits developed in the pes. The vertebræ are biconcave, but the concavities are shallow.

For this second species I propose the name *Notochampsa longipes*. If the two specimens are both adult, then *N. longipes* would probably be about two-thirds the size of *N. Istedana*.

The Stormberg beds until recently have usually been regarded as Triassic. Seward, however, as the result of his study of the plants of the Lower Stormberg or Molteno beds, has recently shown that these beds are of Rhætic age, and as, according to Mr. Du Toit, the horizon of the fossil crocodiles is at least 1,000 feet above the Molteno beds, we are probably safe in regarding *Notochampsa* as of Lower Jurassic age.

A full description of the remains will appear in the Annals of the South African Museum.

In view of the great interest of the discovery the Geological Commission has kindly granted me permission to communicate this preliminary notice to the Geological Magazine.

III.—On the Homotaxial Equivalents of the Lower Culm of North Devon.

By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

I AM glad that my paper on the Coddon Hill beds, published in the Geological Magazine, August, 1904, pp. 392–403, has aroused criticism, and could only have wished that Dr. Vaughan had been familiar with the Carboniferous sequence of the Pennine area and Belgium. The matter is not one to be solved by the casual appearance in any definite bed of a few Brachiopods, at one only of the many horizons at which they are known to occur in other localities, for the whole of the fossils, which are quoted by Dr. Vaughan as the foundation for his argument that the Coddon Hill Beds are low down in the Carboniferous sequence, are equivocal as far as their value as zone indices goes. And on the other hand, Dr. Vaughan completely ignores those fossils which are unequivocal and which denote a well-recognised horizon, and curiously enough, too, correspond with a marked change in lithological character of the Carboniferous sequence. In the first place, I do not see where Dr. Vaughan found any statement in Mr. Howe's and my paper on the Pendleside group at Pendle Hill (Q.J.G.S., vol. lvii) that the Pendleside series are the equivalents of the Millstone Grit of South Wales and the Mendip areas. The table on the page quoted (p. 388) distinctly shows that we consider the Pendleside series to lie universally below beds equivalent to Millstone Grit, and we do not mention the series of the Bristol and Mendip area because we were not well enough acquainted with that district to do so.

To turn to the evidence afforded by the Brachiopoda and Zaphrentoids of Coddon Hill Beds. Every species mentioned in Dr. Vaughan's list occurs in the Pendleside series in the Pendle and Bolland area

and in North Staffordshire and Derbyshire, and my specimens have been kindly identified by Dr. Vaughan, with the exception of *Leptena analoga*, and they occur, not only in typical Pendleside beds, in the type area, but Dr. Vaughan recognises the following species in a small collection I made at Bishopton, north of Oystermouth, Glamorganshire:—

Chonetes aff. *Hardrensis*. *Spirifer* aff. *clathratus*.
Cleiothyris glabristriata.

I also found there one or more species of Trilobites and a *Fenestella*. The latter Dr. Vaughan recognises as present in his Tournaisian of the Bristol area. I have it in my notes that a specimen of a Zaphrentoid coral was found in these beds in my presence. In the Summary of Progress of the Geological Survey of the United Kingdom, 1900, pp. 86–90, the position of these beds is discussed, and it is stated that beds of similar lithological character with rotten stone and Radiolarian cherts occur in the north crop of the South Wales Carboniferous basin as well as at Bishopton. Moreover, Dr. G. J. Hinde is quoted (p. 89) as having found Radiolaria and sponge spicules in specimens both from Carmarthenshire and Glamorganshire.

Further, Dr. Hinde says: "The character of the rock, the mode of preservation of the Radiolaria, and the forms themselves, are very similar to what are found in the cherts with Radiolaria from the Lower Culm of Devon and Cornwall. . . . . And two of the Radiolaria showing structure, *Porodiscus* and *Carposphæra*, are identical species with those figured in the Culm cherts."

There is therefore very strong evidence from Dr. Vaughan's own standpoint that the Bishopton and Penwyllt beds are the equivalent of the Coddon Hill Beds, and these beds overlie the thin-bedded limestones of Oystermouth, which lie above the Oolitic beds of the Carboniferous Limestone sequence.

The Bishopton Beds underlie a series of black shales with

Posidoniella lævis. *Glyphioceras diadema*,
Glyphioceras bilingue.

specimens of which I obtained from the bed of a small stream immediately north of the Bishopton Beds, a fauna never yet found below beds with a Viséan fauna.

If the Bishopton Beds = Tournaisian, where are the representatives of the Viséan in South Wales? This question also is very pertinent in the Coddon Hill district if Dr. Vaughan's views are correct. In that area the researches of Mr. Newell Arber have conclusively demonstrated that the Upper Culm beds are the homotaxial equivalents of the Coal-measures, and he has rediscovered at Mouth Mill, Clovelly, and Instow the fauna mentioned at p. 397 of my paper, which indicate much lower beds. I regret I did not credit him with that discovery in my paper, but I was unaware that this discovery and rediscovery was entirely due to his work, and I take this, the earliest opportunity, of acknowledging my indebtedness to him both directly and indirectly. If Dr. Vaughan's contention is correct that

Coddon Hill Beds are Tournaisian, then either there must be a great unconformity between Coddon Hill and the Upper Culm, or the Viséan beds are represented by beds with a Millstone Grit and Coal-measure fauna and flora.

And yet another question may be asked—Has the fauna which I consider to be typical of the Pendleside series ever been found in beds of Tournaisian age? This point Dr. Vaughan entirely ignores. I am not aware that this has been the case, and hence another difficulty in accepting Dr. Vaughan's views.

We know that at Visé and Clavier, and Chokier, in Belgium, and in Yorkshire, Derbyshire, Staffordshire, North Wales, and the West of Ireland, the Pendleside fauna always succeeds a Viséan fauna, and never occurs below it, and I make this statement after personally examining De Koninck's large collection of types in the Musée Royale d'Histoire Naturelle at Brussels on many occasions, and many years collecting in the Pennine area in England and in the west of Ireland.

I knew that several similar species of Brachiopoda and Zaphrentis occurred both at Coddon Hill and in the Pendle area, but I attached no importance to them as indices of horizons, and did not quote them because I knew they occurred at several horizons. I know of at least three horizons several hundreds of feet apart in the Midlands where Zaphrentoid corals occur abundantly, and to go into details with regard to the Coddon Hill Brachiopoda:—

Chonetes Laguessiana (I still prefer this name) occurs at many horizons from the Calciferous Sandstone series up to the Gin Mine coal, high up in the North Staffordshire Coalfield, being abundant in beds about 2,000 or 3,000 feet below this coal in the Midlands.

Leptena analoga has not such an extensive vertical distribution. I do not know of this shell above the base of the Pendleside series, but it also occurs very low down in the Carboniferous Limestone series.

Rhipidomella Michelini occurs from the Calciferous Sandstone series up to the base of the Millstone Grits.

Cleiothyris glabristriata, Phillips.—Davidson considered this species to be the interior of *Athyris Royssii*, and I am not aware that Dr. Vaughan has yet published his views as to the rehabilitation of this species. At any rate it occurs at Bishopton, and I know of shells like the Bishopton specimen at several horizons.

Spirifer aff. *clathratus*.—This species must remain, for the present, a doubtful one, as we are not yet aware on what grounds Dr. Vaughan desires to re-establish the species. Davidson (Brit. Carb. Brachiopoda, p. 21), discussing *Spirifer striatus*, says, "Professor M'Coy is also of opinion that what he described in 1844 as *Sp. clathrata* must be added to the list of synonyms." M'Coy's type has disappeared, and he only gave a figure of the large or branchial valve without details of beak or area. Also it would be important to know from what locality the type came, and whereabouts in the Carboniferous series.

Spirifer laminosa.—This shell is very common indeed in the Redesdale ironstone, in the Ashfell Beds south of Kirby Stephen, and Dr. Vaughan recognises a specimen of mine which occurs with a Visé fauna at Treycliff, Castleton. The Redesdale ironstone is

over 1,600 feet below beds with a Visé fauna, and *Productus cora* = *P. semireticulatus*, and *P. giganteus* occur with it. So that whatever may be the case at Bristol, it is abundantly plain that none of the Brachiopoda quoted in Dr. Vaughan's paper run true over the Pennine area in England, and on this account I consider them to be equivocal as evidence for the correlation of the two areas; and to repeat it, is the fact that from Visé and Clavier in the east to co. Clare in the west, the strata that immediately overlie the Carboniferous Limestone are characterised by beds containing:—

Posidonomya Becheri.
,, *membranacea.*
Posidoniella lævis.
,, *minor.*
,, *Kirkmani.*
Pterinopecten papyraceus.
Aviculopecten Losseni.
Pseudamusium fibrillosum.
Chænocardiola Footii.
Orthoceras Koninckianum.
Orthoceras Morrisianum.
Glyphioceras diadema.
,, *reticulatum.*
,, *spirale.*
Prolecanites compressus.
,, *mixolobus.*
Nomismoceras spirorbis.
Dimorphoceras Gilbertsoni.
Gastrioceras carbonarium,

and many others, none of which, as far as I know, occur in beds below the Visean limestone.

I think that Dr. Vaughan has greatly strengthened my case that the Lower Culm beds of Devonshire and Cornwall are the homotaxial equivalents of the Pendleside series, having emphasised evidence which I neglected, and I think he will now admit that the Brachiopod and Coral faunas of the Coddon Hill and Bishopton Beds and part of the Pendleside series are identical.

IV.—The Devonian Rocks of Cornwall.

By W. A. E. Ussher.

[By permission of the Director of H.M. Geological Survey.]

SEDGWICK and Murchison, the Rev. D. Williams, and Dr. Holl, taking the Plymouth limestones as a middle division, placed them below the rocks to the south and above those to the north. The prevalent southerly dips of schistosity were regarded as ample evidence of a downward succession proceeding northward.

The Staddon grits and other Lower Devonian rocks were thus placed above the Middle Devonian, and the slates in which I have at various times since 1892 found Upper Devonian fossils (between Menheniot and St. Budeaux) were relegated to a position below the Middle Devonian.

Turning from these more general readings of the geology to the detailed work of De la Beche, as presented in Chapter iii of his Report, we find that this comparatively simple rendering, though fundamentally wrong, cannot be applied to Cornwall.

As regards South-East Cornwall (see p. 79), the fossiliferous Looe beds were said to be prolonged toward St. Germans and to become merged in the trappean rocks, etc., of St. Stephens and Saltash, both being considered as below the Plymouth (Middle Devonian) rocks. The calcareous strata of the Tregantle coast (the same series as the

fossiliferous Looe beds) were taken as the probable westerly continuation of the Plymouth limestones. The latter error was endorsed by me in recording coast observations some years before I had any practical acquaintance with the Devonian rocks of South Devon.

As regards North Cornwall (see p. 91), we read "the slates of Watergate Bay rest on the sandstones of St. Eval and St. Breocks Down; and the red and variegated beds of St. Kew and St. Minver seem to be the same with the red and variegated beds of Watergate Bay; the calcareous rocks of Lower St. Columb Porth, Newquay, and the Gannel representing in a general manner the limestones of Rock, Padstow, and Permizen."

The anticlinal of St. Breocks Down is elsewhere referred to in Chapter iii, and as these grits do not crop up to the north, we are obliged to assume their identity with the Staddon grits.

It will thus be apparent that, as regards South-East Cornwall, De la Beche correlated the Looe beds[1] of the Looe district with rocks in the Saltash district which I have proved to be Upper Devonian, and the same Looe beds in the Tregantle district with Middle Devonian rocks in the Plymouth district. As regards North Cornwall, it will be seen that De la Beche did not treat the variegated slates of Watergate Bay as an anticline, but by assigning that structure to the Staddon grits he correlated the Lower Devonian rocks on the south with the Upper and Middle Devonian rocks on the north.

The Devonian geology of Cornwall prior to 1890 was thus left in a state of chaos. In that year, after two years' careful mapping of the Torquay, Totnes, and Newton Abbot area, I endeavoured, by a thorough perusal of De la Beche's Chapter iii with the maps before me, to follow his minor subdivisions, and to test his correlations in order to ascertain how far they might be made to agree with the subdivisions I had established by detailed survey. I then found that there was no escape from the conclusion that the grits of St. Eval and St. Breocks Down and of Boconnoc represented the Staddon grits which at Mount Edgecumbe are on the mean latitude of their South Devon outcrop. The difference in latitude I conceived to be due to the existence of a great north-westerly fault from Cawsand, *cutting off the Upper and Middle Devonian rocks on their westerly strike against the Lower Devonian subdivisions and shifting the outcrop of the Staddon grits northward.*

I had recognized the lithological affinities of the variegated slates of Mutley to the red and green Entom-yielding Upper Devonian slates of Ansteys Cove, Goodrington, and Highweek (Newton Abbot) in 1888. So that it became evident that the red and variegated slates to the north of the Staddon grits had been confounded with the Dartmouth slates in North Cornwall, and that the anticlinal structure assigned to the grits of St. Breocks Down was suggested by this similarity.

[1] Referred to the Siegener Grauwacke by Dr. Kayser, who established the Taunusian age of the fauna in 1882.

On the other hand, in South-East Cornwall it became evident that the Looe beds had been traced into Upper Devonian on their strike, *through the great structural fault between them having escaped detection.*

The results of this critical examination were contributed to the Royal Geological Society of Cornwall and appeared in the Transactions of that Society in 1891. The paper was entitled "The Devonian rocks as described by De la Beche interpreted in accordance with recent researches." It was accompanied by a map reduced from the 1 inch on which, after tracing De la Beche's minor subdivisions with infinite pains, as far as the information obtainable from the Report enabled me to do, I had *remodelled* them and referred them to *widely different horizons.* This map shows the relations of the Upper, Middle, and Lower groups of the Devonian for the first time, and with approximate general accuracy; it also furnishes the key to the Devonian geology of Cornwall.

Having since mapped the country from Plymouth to St. Austell in detail, I have found the inference of great structural faulting to be correct, the effect being produced by two or three faults, one of which runs in a north-westerly direction from Cawsand, as shown in the little map illustrating the results I arrived at in 1891. By the discovery of the Upper Devonian *Entomides*, *Styliolæ*, and traces of the Büdesheim fauna, I have proved the occurrence of Upper Devonian rocks where shown on the little map east of Liskeard.

In North Cornwall, the discovery of the Büdesheim fauna by Mr. Fox at Trevone and the researches of Mr. Parkinson have proved the general correctness of the map as showing the extension of Upper Devonian. The general line of the Lower Devonian outcrop is correct as far as the occurrence of the Staddon grits could be inferred from the materials in Chapter iii.

These results were achieved by analogy with a carefully mapped district, and they are directly contrary to De la Beche's correlations. As regards the run of the Lower Devonian subdivisions, the map had to be constructed from totally inadequate materials, so that the relative outcrops of the Dartmouth slates and Looe beds, in the absence of analogy, were very incorrectly shown.

An alternative rendering of the structure of Watergate Bay was given, showing the Dartmouth slates as an anticlinal, although not suggested by De la Beche. This structure has since been worked out by Mr. Reid.

I took the Grampound rocks as a base to the Devonian on account of their conglomeratic character and because there is nothing in the Report to show that they partake of the south-westerly strike of the rocks to the south, so that they appeared to mark the unconformable junction of a newer with an older group.

The revolutionary character of my paper of 1891 was pointed out by the late R. N. Worth in an article which appeared in the same Transactions (Royal Geol. Soc. Corn.) for the ensuing year, 1892. In it he criticized adversely the structure put forward, but in a most fair and candid manner. He corrected an error as to the Modbury elvan, which in subsequent mapping was found to be a granophyre.

So far as I am aware, Mr. Worth's criticisms on my paper of 1891 are the only ones that have appeared in print. The title of the paper is misleading, as De la Beche's descriptions merely furnished the material, but the Devonian geology was derived from my own work in South Devon, which gave the clue for separating his minor subdivisions into widely different horizons.

Mr. Upfield Green, in an article on the correlation of some Cornish beds with the Gedinnian of Europe (in the August number of the GEOLOGICAL MAGAZINE), has pointed out my inadvertent use of the term 'Gedinnien' as applied to the Looe beds in 1900, but he has overlooked their correlation with the Siegener Grauwacke in the table of classification in the "Memoir on the Geology of the country around Torquay" in 1903. He has also omitted to state that Dr. Kayser first correlated them with the Taunusien in 1882.[1] Of this I was well aware, as Dr. Kayser had called attention to the fact in a brochure in 1888 giving the results of a trip to the North and South Devon Devonian in company with Professor Gosselet and others under my guidance. In my paper of 1891 I suggested the correlation of the Grampound grits with the Gedinnien; to this Mr. Green does not refer, although I gather from his paper that he places them in the same group that I did then, but hesitate to do now.

In a general way I gather that Mr. Upfield Green places those rocks between the Lizard district on the south and the St. Austell granite on the north, which are not admittedly Silurian, in the Gedinnian, including in that group the Mylor, Falmouth, and Portscatho beds of Mr. Hill, and placing the Dartmouth slates at the top. There is, however, one objection to this, viz., the assumed continuity of the Dartmouth slates "through Tywardreath and St. Austell to St. Stephens as described by De la Beche." I, too, assumed this continuity from De la Beche, but on investigating the ground I found that the Dartmouth slates are cut off by a nearly north and south fault near Tywardreath, and do not extend round the St. Austell granite, either on the north or south margin, to Watergate Bay.

Mr. Upfield Green has raised a very interesting question in claiming the non-Silurian rocks of South Cornwall as Gedinnien, but there is no proof that these rocks are below the Dartmouth slates. To entertain this suggestion the absence of Dartmouth slates on the south of the St. Austell granite would have to be explained by a very improbable change in character, or by a fault between the Perran Porth and Pentuan coasts throwing Gedinnian rocks on the south against the higher beds of the Meadfoot group on the north. Without an acquaintance with the district west of Grampound and Ladock I should not like to express any very definite opinion. Mr. Upfield Green, no doubt inadvertently, states that the Dartmouth slates may be traced "across the Start Peninsula as far as Babbacombe, south of Dartmouth in Devonshire." This

[1] Jahrb. d. kgl. preuss. Landesanstalt., p. 128, 1882.

should read "as far as Scabbacombe Head, east of Dartmouth." He asserts, moreover, that "they exist also on the north of the Devonian basin." There they are represented, no doubt, and in 1889[1] I tentatively classed them with the Foreland grits as Gedinnien but there is no distinct group of similar character in North Devon or West Somerset.

V.—The Older Deutozoic Rocks of North Britain.

By J. G. Goodchild, F.G.S., of the Geological Survey,
Curator of the Collections of the Geological Survey of Scotland in the Royal Scottish Museum.

IT appears to be a common belief that there are two Old Red Sandstones in Scotland, and only two, which are referred to respectively as the Upper and the Lower. It is generally recognised that neither of these can be paralleled with any one of the subdivisions of the Devonian Rocks, properly so-called; though the fact that the Scottish rocks in question occupy a stratigraphical position somewhere between the top of the Silurian Rocks and the base of the Carboniferous System places their Devonian age beyond the possibility of a doubt. The Upper Old Red is considered by most persons to graduate upwards into the Carboniferous Rocks, which, by the way, is by no means universally the case. It is also stated, with equal confidence, and with as little regard to the facts, that the Lower Old Red Sandstone graduates downward into the Silurian Rocks, which it certainly does not, as will be shown more fully in another part of this paper. Furthermore, it is still commonly believed that bands yielding Silurian graptolites alternate with the base of the Lower Old Red Sandstone, and that Lower Carboniferous fossils occur in bands of rock interstratified with true Upper Old Red Sandstone. Both of these ideas are well known to have been due to errors of observation; yet the statements in question, having found their way into the papers set by examiners, seem destined to die a hard death, and therefore need to be contradicted.

The errors mentioned are by no means the only ones relating to the rocks of Devonian age in North Britain. Therefore, as no one else who is fairly well acquainted with these rocks has yet come forward with the object of stating the actual facts, I propose to take advantage of the present opportunity (when I am about to present some new suggestions regarding the age of some volcanic rocks on the northern margin of the Lake District) to give a conspectus of what is at present known about the Scottish rocks of Devonian age.

As much of the evidence bearing upon this subject is necessarily of a palæontological nature, I gladly avail myself of some of the published results of the important work done in this direction by Dr. Traquair, and accordingly give here lists of such fossils as serve to characterise the several horizons referred to. A list of

[1] Proc. Somerset Arch. and Nat. Hist. Soc., vol. xv, pt. 2, Table of Classification, in which 'Gedinnien' is placed in line with Lynton Beds through a printer's error.

such of Dr. Traquair's papers as bear upon this part of the subject is given in an appendix to the present paper.[1]

It need hardly be stated here that the Scottish rocks of Devonian age differ in almost every respect from the normal type. There is no satisfactory reason for regarding any of them as of marine origin; and, on the other hand, there is much to be said in support of the view that they were all formed under continental conditions, and under conditions of climate which, though doubtless varying much from time to time, were yet, on the whole, characterised by an annual rainfall decidedly below the average in amount. It is this feature which has imparted a common character to the whole of this series of rocks.

We may now proceed to review such of the chief points of interest connected with each of the Old Red Sandstones as bear more or less directly upon the chief matter to be discussed in this paper.

The newest subdivision of the Old Red Sandstones is the well-known Upper Old Red. This, by the way, *is* usually red in colour, and, also, it does consist mostly of sandstones. The remark is not altogether uncalled for, as much of the remainder of the Old Red is not red, and it does not, by any means, consist exclusively of sandstones. The Upper Old Red was formed at a period when the geographical conditions were slowly changing from those of a continental nature to those of an insular type. The rocks are, of course, extremely variable in thickness, because they were laid down upon a very uneven surface of the old land. They are also, but to a lesser extent, variable in mineral character. But where this formation is most fully and typically developed its petrographical characters may be described as referable to three types—(1) a basal conglomerate, which graduates upward into (2) a variable series of red sandstones, often full of desert-sand grains, and highly false-bedded in places, like an old desert sand-dune. This part is mainly red, with some poikilitic mottling and variegation. A few bands of marl[2] occur here and there. Calcareous matter is usually conspicuous by its absence from this division. Above this group of red rocks usually occurs (3) a higher subdivision, in which the sandstones are not so deeply coloured, and in which even purplish bands begin to occur. This upper group is generally characterised by the occurrence in it of some precipitated carbonate of lime. In some cases this compound occurs in the form of flakes, which obviously represent broken-up sheets of chemically-formed carbonate of lime; in other cases the calcareous matter has segregated into a nodular form; while in some few instances the calcareous matter may occur as lenticular masses closely resembling some bedded limestones.

[1] In here referring to it, I may perhaps be permitted to direct the reader's special attention to the beautiful and lifelike restorations of the fishes of the Orcadian Rocks which Dr. Traquair has given in Harvie Brown's "Vertebrate Fauna of the Moray Firth."

[2] The word 'marl' in the North means any clay that readily crumbles on exposure to the weather.

This upper subdivision is usually referred to as the Cornstone Series. I have suggested in several papers that this chemically-formed carbonate of lime of the Upper Old Red Cornstones marks a transitional phase of climate. The land had sunk to near the sea-level, and consequently humid conditions had set in, and vegetation had begun to flourish. The decomposing remains of trees, drifted into the lagoons, led to a precipitation of carbonate of lime from the sulphate of lime held in solution by the concentrated sea-water there. The presence of these cornstones is, therefore, useful to the geologist as indicating transitional phases of climate from arid to humid. Conversely, seeing that the same climatal conditions must have prevailed over wide areas, the occurrence of cornstones at several localities within an area of limited extent might safely be trusted as evidence of their contemporaneity. The validity of this reasoning has lately been put to a very severe test, which, I may add, it has successfully withstood.

The fauna of the Upper Old Red consists almost exclusively of fishes, which probably found their way into the sediments from the rivers of upland origin, whose waters were dissipated by the excessive evaporation when they reached the lowland areas. The fish belong to species, and in some cases to genera, not found elsewhere. Hence their remains serve a valuable purpose in determining the age of the rocks in which they are found. Amongst other fossil fishes may be mentioned such Crossopterygians as *Holoptychius* and some of its allied genera; the Ostracoderms *Asterolepis*, *Bothriolepis*, and others; such Dipnoans as *Phaneropleuron*, together with some other genera of equal biological interest, but as zonal forms of lesser interest to the geologist. Dr. Traquair has shown that the Upper Old Red contains two distinct fish faunas. The lower zone is characteristically developed around Nairn, and the higher is well seen near Elgin.

It is not strictly correct to speak of the Upper Old Red Sandstone graduating upwards into the Carboniferous Rocks; and, for the same reason, it is equally incorrect to describe this formation as the "Carboniferous Basement Bed." There can be no doubt that the Upper Old Red is quite a separate formation from the Carboniferous System, and it has certainly nowhere been seen to alternate with any rocks of undoubted Carboniferous age. In Central Fife there is a very marked overlap of the middle of the Lower Carboniferous Rocks on to the Upper Old Red Sandstone; and evidence is not wanting elsewhere of something like a true unconformity between the two formations.

As regards the base of the Upper Old Red Sandstone, it has long been known that, throughout Britain, it lies with a more or less violent discordance upon the rocks beneath. In Cumberland and Westmoreland the aggregate thickness of the rocks between the highest and the lowest horizons of the Protozoic rocks upon which it lies amounts to more than seven miles, i.e. 13,000 feet of Silurian Rocks, 12,000 feet of the Bala–Arenig volcanic rocks, and fully 12,000 of the Skiddaw Slates, to say nothing of other formations

to be presently referred to. One of the most impressive geological phenomena I ever witnessed was presented by a section in the Basin of the Lune, of the Upper Old Red Sandstone lying in a nearly horizontal position upon vertical and highly-cleaved Upper Ludlow Rocks, of fragments of which the newer rock was largely composed. This was in the course of my first week's field-work on the Geological Survey, in 1867. Ever since then my recollection of that enormous hiatus has remained as vivid as at first, and it has added not a little to the pleasure afforded by somewhat extensive explorations made in recent years amongst the Scottish rocks which partly bridge over the vast gap. An unconformable junction of Cornstones on Highland Schists, exposed on the north shore of Arran, is hardly less striking; as is the better known case at the Siccar Point, where the Upper Old Red lies upon Gala Rocks.

Unconformable Junction of Cornstones with Highland Schists, north shore of Arran, east of Loch Ranza.

It adds still further to the impressive character of the unconformity at the base of the Upper Old Red Sandstone of the Lake District that this rock also contains rolled fragments of the granites, elvans, and porphyrites of that part. These plutonic and trappean rocks are certainly of later date than the cleavage of the rocks they invade and also than one phase of the great denudation that followed the development of the cleavage. That is to say, after the Protozoic rocks of the Lake District were folded, they were first cleaved, then denuded to an enormous extent; after that, great volcanoes rose upon the denuded surface, and, finally, the volcanoes themselves

were gradually worn away to the very cores—all before the Upper Old Red Sandstone began to be laid down.

The full importance of this stupendous unconformity has not yet, I think, been adequately realised. When its significance comes to be thoroughly grasped much greater interest than is shown at present will be felt in the geological formations which help to fill in part of the gap. Most of these, as is well known, occur north of the Tweed.

The newest formation of these Old Reds, of prior date to the Upper, is the Orcadian Series, which is so extensively developed in the north-east of Scotland and in Orkney and Shetland. The Orcadian Series has formed the subject of several important memoirs, amongst the latest of which may be mentioned those by Messrs. Peach & Horne, Sir Archibald Geikie, Mr. Evans, and Dr. Flett. Even the highest beds of this formation lie unconformably below the Upper Old Red; and neither the natural top of the Orcadian Series nor its base has yet been found. Nevertheless, the thickness of this older subdivision, where it is most fully developed, has been estimated at some sixteen thousand feet. Three well-marked fossiliferous horizons occur within it. The highest one occurs in the upper beds, or John o' Groats Flags. This has yielded several fossil fish which have not been met with on any other geological horizon. Amongst these are *Tristichopterus alatus*, Egert., *Dipterus macropterus*, Traq., and *Microbrachius dicki*, Traq.

Lower down, and on horizons which are near the middle of the series, if we have regard to the maximum development of these rocks, come the fossiliferous beds of Thurso; and, still lower, those of Achanarras and Stromness, as well as at Cromarty and other places near the Moray Firth. Below these, again, come the Sandstones of Berriedale, the Badbea Breccia, and some local conglomerates. These three last-named subdivisions form the lower four thousand feet or so of the Orcadian Series; but in the absence of any satisfactory palæontological evidence their position in relation to the highest of the rocks forming the next older series cannot be fixed with certainty.

From the Thurso Flags Dr. Traquair has identified *Homosteus milleri*, *Coccosteus decipiens*, *C. minor*, *Mesacanthus peachi*, *Cheiracanthus murchisoni*, *Diplacanthus striatus*, *Rhadinacanthus longispinus*, *Glyptolepis paucidens*, *Gyroptychius microlepidotus*, *Osteolepis microlepidota*, *Thursius macrolepidotus* and *Th. pholidotus*, *Diplopterus agassizi*, and *Dipterus valenciennesii*.

The lower or Achanarras subdivision contains a fish fauna which Dr. Traquair has identified as follows: *Diplacanthus striatus* and *D. tennistriatus*, *Rhadinacanthus longispinus*, *Mesacanthus pusillus*, *Cheiracanthus murchisoni* and *Ch. latus*, *Pterichthys milleri*, *Pt. productus* and *Pt. oblongus*, *Dipterus valenciennesii*, *Glyptolepis paucidens*, *Gyroptychius microlepidotus*, *Osteolepis macrolepidota*, *Diploterus agassizi*, *Coccosteus decipiens*, *Homosteus milleri*, and *Cheirolepis trailli*.

The fossiliferous portions of the Orcadian Old Red do not occur to the south of a westerly line drawn through Stonehaven. Whether

the beds below the lowest of these horizons do so or not cannot be determined at present in the absence of any palæontological evidence; but there is a general belief amongst those who have the means of forming an opinion that these lowest beds are, like those above them, confined to the northern area referred to.

To the south of the line just indicated there occurs another formation, the general biological facies of whose fossils indicate, as J. W. Salter pointed out nearly half a century ago, a lower horizon than the Orcadian Old Red. In places this formation, also, is capped by the Upper Old Red, which here, as elsewhere, lies unconformably upon the rocks below. The formation to which reference is now being made has been termed the Lower Old Red Sandstone by several writers; but as there is another and still older formation which has also received that name, and as even the Orcadian Old Red has been also called the Lower Old Red, it is obviously better, in referring to these subdivisions, to make use of some territorial name, in order to prevent ambiguity. Therefore, many geologists who have felt the difficulty referred to have adopted the name Caledonian for this southern Scottish formation. This, besides being euphonious, and also useful in many ways, is rendered the more appropriate because the rocks denoted by that name were considered by Sir Archibald Geikie to have been formed in a lake to which he gave the name 'Lake Caledonia,' and furthermore, because this formation is pre-eminently the Old Red of Scotland, and because it is typically developed in the region distinguished by the Romans as Caledonia.

Like the Orcadian Old Red, the one under notice attains to a very considerable thickness. Sir Archibald Geikie, indeed, estimates that thickness at 20,000 feet (Text Book, vol. ii, p. 1008). Its natural top is not seen; nor, perhaps, is its base. As regards its mode of origin, there appears to be evidence of a satisfactory nature that the whole of this vast formation was accumulated under continental conditions, partly in large inland lakes, partly as torrential deposits of various kinds, partly as old desert sands, and partly as the results of extensive volcanic action. The lowest strata appear to be those which are exposed near Dundee, where they are brought up by a powerful anticlinal fold, whose effects are, I think, augmented by a large fault which does not appear to have been hitherto recognised. Most of the base on the north is faulted in by the Highland Boundary Fault. The newest strata are exposed in the western part of the lowland tract of Strathmore, along a powerful synclinal, which is correlative to the anticlinal just referred to.

Looking at the formation broadly, three subdivisions, founded upon petrographical characters, can be made out. The highest of these is formed by the conglomerates, sandstones, flags, and marls, whose outcrops form the great lowland tract of Strathmore. The middle subdivision consists chiefly of volcanic rocks, which are mostly andesitic lavas, with some quite subordinate beds of tuff. This volcanic series forms the Ochils and the Sidlaw Hills, in the

part of Scotland at present under notice. To the north and north-east of Dundee the volcanic rocks pass, by the thinning of the lavas, into a series of alternately sedimentary and volcanic rocks—the sediments in this case being, therefore, contemporaneous with some of the volcanic rocks to the east. The confusion occasioned by this feature appears to be further complicated by the anticlinal and its accompanying fault just mentioned. It should be noted that these volcanic rocks form a very conspicuous feature in the stratigraphy of the Caledonian Old Red, and that they are usually present, in some form or other, even when the lower beds and the upper are entirely absent.

The Caledonian Old Red volcanic rocks of Perth and Forfarshire may well be several thousand feet in thickness where they attain their fullest development. Sir Archibald Geikie (loc. cit., p. 1008) further regards the volcanic horizon as occurring several thousand feet below the highest beds of Strathmore, and also as being several thousand feet above the base of the system.

The volcanic zone certainly overlies a considerable thickness of greywackes, flagstones, and mudstones, whose base has not been seen. These lowest sedimentary beds, it may be here remarked, bear a remarkably close petrographical resemblance to the type which forms much of the Silurian rocks; and it may be well to add that the physical relationship of these Arbroath Flags (as they may still be called) to the volcanic belt has not yet been quite clearly made out.

Turning now to the palæontological evidence, it may be said that very few fossils have yet been obtained from the higher parts of the Strathmore Sandstones; so there is no evidence to prove that these beds may not be contemporaneous with the very lowest subdivisions of the Orcadian Series. Near the base of the Strathmore Sandstones, and close to the top bed of the main part of the volcanic rocks, occurs an upper fossiliferous band which has yielded myriapods such as *Kampecaris* and *Archidesmus*, together with imperfectly preserved plants, some of which have been referred to *Psilophytum robustum*; while at a slightly lower horizon, and contemporary with some of the volcanic rocks, is the zone which has yielded the chief Acanthodian fish remains. One of the best known of these fossiliferous localities is at Tilliewhamland Quarry, Turin Hill, near the town of Forfar. These rocks are there extensively quarried for flagstones, and they have yielded fossils which have been catalogued by the late Mr. Powrie as follows:—*Mesacanthus mitchelli*, *Ischnacanthus gracilis*, *Climatius scutiger*, *C. uncinatus*, *C. reticulatus*, *Parexus recurvus*, *P. falcatus*, *Euthacanthus mitchelli*, *E. elegans*, *E. gracilis*, *E. curtus*, *Cephalaspis pagei*, *C. asper*, *Thelodus pagei*, and with *Pterygotus anglicus*, *Stylonurus ensiformis*, and also with *Parka decipiens*, etc. Similar beds occur near this horizon at Farnell.

The beds exposed at Turin Hill are on the north limb of the great faulted anticlinal above mentioned. The axis of this anticlinal ranges, roughly speaking, from near the confluence of the Earn with the Tay, below Perth, through a point about midway between the

towns of Dundee and Forfar, and thence in the direction of Montrose. Hence the fossiliferous horizon represented at Turin Hill is repeated to the south of the line mentioned.

At a geological horizon lower still, as at Auchtertyre, near Newtyle, in Forfarshire, but still above the main mass of the lavas, occurs a bed which has yielded *Cephalaspis lyelli, Pteraspis mitchelli,* and some few Acanthodians.

Furthermore, at what I take to be still lower fossiliferous horizons, occur the beds of Carmylie, which have yielded most of the finest specimens of Eurypterids obtained from Forfarshire. Acanthodians of the types occurring at Turin Hill are found with these, as is also *Parka decipiens.*

What appear to be the lowest fossiliferous horizons occur at Myreton, Tealing, and Leoch.

The general biological facies of these Caledonian Old Red fossils indicates, according to Dr. Traquair, a formation of an earlier date than the Orcadian Old Red. This view of the relative positions of the Caledonian and Orcadian Old Red formations has now again met with general acceptance, and it will probably never again be called in question.

The volcanic rocks which have just been mentioned as giving rise to the most prominent features of the Caledonian Old Red in the Ochils and the Sidlaw Hills present physiographical features of even more strongly-marked character in the Pentland Hills, in Glen Coe, and also in the neighbourhood of Oban. The Cheviot Hills, again, owe much of their physiographical character to the presence of these rocks. St. Abb's Head, and some other places near that part of the Scottish coast, also consist of andesitic lavas and tuffs of the same age as those of the Pentland Hills and the Ochils. Here and there at several localities south of the Firths of Forth and Clyde the older sedimentary rocks below the volcanic zone are to be seen. As a well-known locality where such is the case may be cited the beautiful river-gorge in which are situated the Falls of Clyde. More generally, however, these sediments are absent, and the volcanic rocks form the lowest member of the series, and these may lie, often with a violent unconformity, upon any rock older than themselves.

Most of the granite bosses of the southern half of Scotland, and perhaps nearly all of those in the north of England, appear to have originated in connection with the volcanoes from which these Caledonian Old Red andesitic lavas and their associated dykes of Elvan and Porphyrite have been erupted. Where these Granites and Porphyrites occur we may, therefore, expect to meet at no great distance with remains of their related volcanic rocks.

Leaving these details, however, for reconsideration presently, we may now go on to consider the nature of the physical relation of the Caledonian Old Red to the rocks next older in the series. So far from graduating downward into the Silurian rocks, the local base of the formation under notice lies with a violent unconformity upon all of these rocks, and may repose indifferently upon Silurian, Ordovician,

or even older strata, including the metamorphic rocks of the Southern Highlands of Scotland. What has been taken as the Caledonian Old Red in the cases where it has been supposed that a passage exists is in reality a series of quite different age. These rocks to which reference has just been made, being typically exposed in Lanarkshire, I have named the Lanarkian Rocks. These are the strata which, with part of the Upper Ludlow rocks, have lately been termed the Downtonian Series—a particularly ill-chosen name, as it seems to me, because the name Downtonian had previously been used to denote all the Silurian strata above the top of the Lower Ludlow Rocks. These Lanarkian Rocks form the upward continuation of the true Ludlow Rocks, and they clearly mark the oncoming of the continental conditions which brought the Silurian Period to a close, and marked the advent of those geographical conditions which ushered in the Devonian Period in what is now the northern part of the Kingdom. Their stratigraphical details need not be given here, for the reader will find them fully described in the Geological Survey Memoir on the Silurian Rocks of the Southern Uplands of Scotland—which, by the way, is one of the finest memoirs issued by the Department to which I have the honour to belong.

A study of the excellent sections given in the work just referred to will suffice to show that the Lanarkian Rocks have shared in all the disturbances to which the Silurian Rocks have been subjected. These disturbances had ceased, and had been followed by prolonged denudation, long before the oldest member of the Caledonian Old Red was laid down. Hence it results that the great unconformity, so often referred to, passes above what is left of the Lanarkian Rocks. There is no clear evidence of any unconformity below them.

If we take the original red colour of the sandstones in these Lanarkian rocks as evidence of their representing the very lowest 'Old Red' (which it seems reasonable to do), then it would be these rocks which form the true 'Lower Old Red,' and as such they were most admirably described many years ago (1860) by Sir Archibald Geikie. There are, however, no rocks containing Silurian fossils above them, nor do they present anywhere more than an accidental appearance of a conformable passage into the Caledonian Old Red; indeed, in the only section where these two have the same dip their interrelationship is similar to that of the Trias on the Upper Old Red near Elgin.

I have formerly ventured to speculate (on what seem to me to be good grounds) whether these Lanarkian Rocks might not have formed the lowest part of a very much thicker series of rocks, whose higher portion is now entirely absent through denudation effected prior to the Caledonian Old Red period; and I still think that these missing rocks may have included a band of marine limestone closely resembling the Devonian Limestone, as this is seen at Plymouth, due to a temporary return from continental to marine conditions.

At any rate, and however this may have been, these Lanarkian Rocks, which are certainly posterior in age to the Ludlow Rocks,

are separated from the strata containing *Cephalaspis lyelli* by one of the most extensive unconformities in the whole geological series.

It may serve a useful purpose to summarise here, in a tabular form, the foregoing statements regarding the stratigraphical relations of the various Scottish Old Reds, which, accordingly, is as follows:—

OLDER DEUTOZOIC ROCKS, as developed in Scotland.

	Approximate thickness in feet.
UPPER OLD RED SANDSTONE.	
2. Higher subdivision, or Elgin Beds.	
1. Lower subdivision, or Nairn Beds.	0.—1,000.
[*Extensive unconformity.*]	
ORCADIAN OLD RED.	
5. John o' Groats' Flags.	
4. Thurso or Rousay Beds.	
3. Achanarras, Stromness, and Cromarty Beds.	
2. Berriedale Sandstones.	
1. Badbea Breccias and Basal Conglomerate.	0.—16,000.
CALEDONIAN OLD RED SANDSTONE.	
3. Strathmore Sandstones (the upper part of which may be contemporaneous with the lowest part of the Orcadian).	
2. Myriapod Beds. Volcanic Rocks. Acanthodian Beds of Turin Hill. *Cephalaspis* Beds of Auchtertyre. Volcanic Rocks. *Pterygotus* Beds of Carmylie, etc. Tealing Beds.	
1. Lower Series of Sandstones, Mudstones, Conglomerates, etc.; base not seen.	Ranging to ? 20,000.
[*Extensive unconformity.*]	
The Lanarkian Rocks (Downtonians of the Geological Survey, the original Lower Old Red of earlier writers).	
Ludlow Rocks.	

It will thus be observed that what has been called "The Old Red Sandstone" in Scotland is by no means a single formation; nor can it be regarded as merely two. On the contrary, it must be obvious from a consideration of the foregoing statements that we are dealing with a succession of formations, which, it seems to me, must collectively have required a period of enormous length for their accumulation. This, it will be noted, is evidenced not only by the great thickness of both sedimentary and volcanic rocks accumulated, but also by the extensive unconformities, and equally so by the numerous and important palæontological changes which are known to have taken place during the period in question.

In reflecting upon these facts the chief interest centres upon the formations which are of older date than the Upper Old Red Sandstone and newer than those of Silurian age. If the remains of so varied and important a set of geological formations can be shown to exist even yet in Scotland, one is led to enquire whether it may

not be possible that remnants of some of these may also exist on the English side of the Border, perhaps concealed beneath newer formations, or, it may be, even exposed at the surface in places where their identity has not hitherto been recognised.

As regards the possibility of these rocks occurring in the Lake District, it should be borne in mind that there are two lines of evidence which clearly point to the existence, in former geological times, of andesite volcanic rocks of the types which occur so widely throughout the Caledonian Old Red. One of these is, as I pointed out many years ago, the fact that the Upper Old Red of North Cumberland partly consists of pebbles and blocks of these lavas. These andesite pebbles are so abundant in some places, as, for example, near Melmerby, that I have long entertained the belief that a large tract of these Caledonian Old Red lavas must exist at no great distance, they being covered, of course, by rocks of later formation. Then, again, there is the well-known fact that several of the granite bosses and Elvan and Porphyrite dykes of the Lake District are of later date than the cleavage of the rocks around them, and are later even than the great denudation which preceded the formation of the Upper Old Red. Furthermore, fragments of these granites and their apophyses, as already stated above, occur in the conglomerates of the Upper Old Red. Lastly, the close resemblance in mineralogical constitution of these Lake District granites to those of the South of Scotland, which can almost be proved to represent the deep-seated parts of the cores of the Caledonian Old Red volcanoes, forms an additional link in the chain of evidence which points to these Lake District granites being contemporaneous with the later part of the Caledonian Old Red, and to their marking the sites of areas from which, at one time, andesitic lavas must have overspread the districts around.

During the past sixteen years it has been one part of my duty to arrange for exhibition in the Edinburgh Museum of Science and Art a very large series of Scottish Fossils, Minerals, and Rocks, amongst which last figure very largely representatives of the Scottish rocks of Devonian age. A large proportion of these rocks I have also studied *in situ*, always regarding them when doing so with considerable interest, as representing part of the series that must, in some one place or another, fill up the great hiatus between the Upper Old Red and the Protozoic Rocks of Cumberland and Westmoreland. Whenever a suitable opportunity has presented itself, I have taken advantage of it to go carefully over the field evidence presented by the district just named. There is one part of the Lake District in particular to which I have devoted attention at various times since 1873, and that is the part lying to the north and north-east of Saddleback. A thick series of basic andesite lavas with some tuffs occurs there. These pass unconformably beneath the Lower Carboniferous Rocks to the north and east; and their base, in the opposite direction, comes into contact with sedimentary rocks which are certainly very low down in the Skiddaw Slate Series.

Furthermore, there is a wide divergence in the strikes of the two series, and the volcanic rocks dip, as a whole, in the opposite direction to that of the sediments. Dr. Marr made a very important discovery of sediments of Lower Bala age, the Drygill Shales, near the margin of these. I still think that these Drygill Shales may lie unconformably upon some part of the Skiddaw Slates, and for a long time thought that the set of volcanic rocks at present under notice might possibly belong to an horizon near to that of the Drygill Shales. However, recent visits to the Caldbeck Fell area, with the facts summarised in the foregoing part of this paper in mind, have led me to alter that opinion. Therefore, although I am not aware as yet of any palæontological evidence which tells either the one way or the other, the balance of field evidence seems to me now to indicate that the volcanic rocks in question may really be of the same age as the Caledonian Old Red.

The strip referred to is that which, lying within the Carboniferous frame on the north side of the Lake District, stretches, everywhere with a strike discordant to that of the adjoining Skiddaw Slates, from Uldale, past Caldbeck, through the Caldbeck Fell mining area, to Carrok Fell, and is continued as faulted inliers at two places near Greystoke Park, including the well-known patch which is locally called Berrier Nittles, but which Mr. Ward referred to as Eycott Hill.

There is nothing in either the petrographical or the lithological characters of these rocks which would definitely link them on with the true Arenig–Llandeilo rocks which occur between Keswick and Ambleside, or Ullswater and Shap. On the other hand, the volcanic rocks in question agree in both petrographical and lithological characters with the volcanic rocks which form the Cheviot Hills, and they appear, as the Caledonian Old Red rocks do everywhere, to lie with a violent unconformity upon any rocks older in the series with which they may come into contact.

Whether any of the volcanic rocks near Melmerby can also be referred to this horizon is a question I hope to be able to answer soon.

R. H. Traquair, "Notes on the Nomenclature of the Fishes of the Old Red Sandstone of Great Britain": Geol. Mag., Dec. III, Vol. V (1888), pp. 507–517.

——— "On the British Species of Asterolepidæ": Proc. Roy. Phys. Soc. Edinb., vol. xi (1892), pp. 283–286.

——— "On the Discovery of *Cephalaspis* in the Caithness Flags": Ann. Scott. Nat. Hist., Oct. 1893, pp. 206–207.

——— "Achanarras Revisited": Proc. Roy. Phys. Soc. Edinb., vol. xii (1894), pp. 279–286.

——— "The Fossil Vertebrata of the Moray Firth Area": contained in Harvie-Brown & Buckley's "Fauna of the Moray Basin," Edinburgh, 1896.

——— "Note on the Fossil Fishes of the Old Red Sandstone of Scotland": contained in Mem. Geol. Surv., "Geology of Lower Strathspey" (Explanation of Sheet 85), 1902, pp. 81–82.

VI.—On the occurrence of Lower Miocene Beds between Cairo and Suez.

By T. Barron, A.R.C.S., F.G.S.

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IT is remarkable that in this district so accessible to geologists and visited by so many observers, the presence of these beds has not hitherto been noted. When it is understood that the point where the main area occurs is only between 8 and 9 kilometres from Cairo, and lies immediately to the north of the Petrified Forest—a place visited by nearly all the travellers who come to Cairo—one is apt to doubt whether geologists have ever seriously examined this district.

It has been asserted by some geologists that Lower Miocene beds have been found at various places in this district, but on investigation it has always been shown to be a misinterpretation of the evidence, and up to the present no beds have been noted which contain a true Lower Miocene fauna.

In 1900 MM. Fourtau and Depéret published a paper[1] in which they claimed to have found at Gebel Genêffe beds containing a fauna belonging to the Upper Burdigalien (first Mediterranean stage), and analogous to that found in the basin of the Rhône, of Corsica, and still more to the Cartennian Sandstone of Algeria. They based their assertion mainly on the presence of *Pecten Tournali*, de Serres, *P. præscabriusculus*, Font., *P.* cf. *sub-benedictus*, Font., and *P. Kochi*, Loc. It is stated that the same beds are found at Dêr el Bêda containing *Pecten pseudo-Beudanti*, which is identical with the species of the Hornerschichten of Austria; at Wadi Gafra, where *Pecten pseudo-Beudanti*, *P. præscabriusculus*, Font., and *P. geneffensis*, Fuchs, are found; and these occur in all the district to the east of Cairo. These observers publish another section which they regard as the continuation of the Miocene series, and the representative of the Helvetian-Tortonian (second Mediterranean).

Blanckenhorn[2] says that he has not been able to find the above-named Pectens (except *P. geneffensis*) on the spot, or in Schweinfurth's collection or any other material at his disposal, and recognises them[3] as his new species *P. submalvinæ*, Blanck., and *P. Fraasi*, Fuchs, whilst *P. pseudo-Beudanti* he makes *P. Schweinfurthi*, Blanck., all of these being Helvetian fossils. He[4] also regards the two sections of Fourtau and Depéret as not superposable, but parallel to each other, and by their fossils belonging to the Middle Miocene.

In his discussion of all the previous work done on the Miocene

[1] "Sur les terrains néogènes de la Basse-Egypte et de l'isthme de Suez": Comptes Rendus des Séances de l'Acad. des Sciences, 1900, pp. 402–3.

[2] "Das Miocän": Zeitschr. d. Deutsch. geolog. Gesellschaft, 1901, pp. 52–59.

[3] Ibid., pp. 120–127.

[4] Ibid., p. 85.

rocks of Egypt, this author points out that, previous to his own examination of the area at Mogara in the Libyan Desert, no Lower Miocene beds were known in Egypt. Up to the present this is the only occurrence, but he points out that strong probability exists that these beds will be found in the district between Cairo and Suez, although none have been proved. After discussing and comparing the Petrified Forest near Cairo with that occurring at Mogara, which this author regards as Lower Miocene, he finally decides to put the gritty beds occurring above the basalt to the east of Cairo, together with the Petrified Forest in part, into the Lower Miocene. For this he has no fossil evidence whatever; and it is only from the resemblance between the lithological characters of the beds, and the fact that fossil wood occurs at the base of the Miocene in Mogara (a fact of little stratigraphical value since fossil trees are known from the Upper Eocene, and Oligocene on the other side of the Nile Valley), that he ventures to assign to these beds a Lower Miocene age.

In the course of this paper it will be shown that this decision is partly right, though in the main it is wrong, while in a later paper it is hoped that the much vexed question of the age of the Petrified Forest in this neighbourhood, with its associated lava-flows and thermal springs, will be definitely settled.

In order to better understand the occurrence of the beds in question, a brief sketch of the geological history of the period immediately preceding the Miocene is necessary. After the close of the Eocene period, the land on the east side of what is now the Nile Valley rose from under the sea and became dry land. This was the beginning of a continental period which persisted throughout Oligocene times. While in the district round the Fayum the sedimentation continued unbroken from the highest Eocene into the Lower Oligocene, on the east side of the present Nile Valley denudation was at work removing the Upper Eocene beds and producing the relief seen wherever the Gebel Ahmar Sands have been removed. Then these sands and gravels with drifted trees were deposited in a lagoon or estuary. These probably represent the upper part of the Lower Oligocene. After the sedimentation of these sands had continued for some time, a series of earth-movements were set up, by which these beds with the underlying rocks were thrown into ridges and troughs by two sets of folds more or less at right angles to each other, the axes of the one lying S.W.–N.E., and the other N.W.–S.E. These folds gave rise to shallow basins by their interference with each other, and it was in these that the Lower Miocene beds were deposited, after the outpouring of the basalt lavas, and the thermal springs which followed the dying out of the volcanoes had ceased. Between the deposition of the Gebel Ahmar Sands and the transgression of the first Mediterranean sea, there was another continental period during which these sands were denuded to a certain extent. After the Lower Miocene sea had invaded this area and was depositing its sediments, what more

likely than that some of the silicified tree trunks were rolled in from the ridges surrounding these basins? Any silicified wood seen by the writer in Miocene beds has always been much broken up, and presented the appearance of having been moved after silicification rather than that of petrifaction *in sitû*. One has only to compare the trees in the Petrified Forest with these to see the difference.

According to Blanckenhorn [1] the Lower Miocene is a fluvio-marine formation characterized in Mogara by *Mytilus aquitanicus*, *Cytherea erycina*, and Anthracotherian bones. The Helvetian, on the other hand, has a numerous pecten and oyster fauna associated near its base with a more shallow-water assemblage of forms. In fact, the Lower Miocene is essentially a fluvio-marine formation, while the Helvetian is marine.

This author, in his Table of Miocene Strata in Egypt and Syria,[2] gives the following fossils as characteristic of the Lower Miocene of Mogara :—

Scutella Zitteli, Beyr.; *Mytilus aquitanicus*, M.E.; *Lucina ornata*, Ag.; *Lucina columbella*, Lam.; *Cardium* cf. *taurinum*, Micht.; *Venus ovata*, Penn.; *Cytherea erycina*, L.; *Corbula revoluta*, Brocc.; *Teredo Mediterranea*; *Turritella terebralis*, Lam.; *T. cathedralis*, Brongn.; *Crepidula cochlearis*, Bast.; *Galerus chinensis*, Lam.; together with fossil wood, *Podocnemis*, *Trionyx*, *Crocodilus*, *Brachyodus*, and *Rhinoceros*. In addition to these the following are given in the table of fossils for the Miocene [3] as occurring only in the Lower Miocene :— *Cupularia* cf. *urciolata*, Lam.; *Anomia ephippium*, var. *squamula*, L.; *Cardita rufescens*, Lam.; *Diplodonta rotundata*, Mont.; *Cardium paucicostatum*, Sow.; *Dosinia Adansoni*, Phil.; *Tapes Basteroti*, Desh.; *Tellina* cf. *exigua*, L.; *Ervilia pusilla*, Phil.; *Mactra burdigalensis*, May.; *Corbula Basteroti*, Hörn.; *Tugonia anatina*, Gmel.; *Oliva clavula*, Lam.

It is now possible to proceed to the description of the beds for which a Lower Miocene age is claimed.

Between 8 and 9 kilometres east of Abbassia there occurs a series of ridges of gritty limestone, calcareous grits, and ferruginous, calcareous, sandstones and grits, bounded on the south by a thin sheet of basalt, and faulted down on the north along the side of the Old Post Road to Suez. They persist to the north of this fracture, but are much masked by gravel and downwash. This series of beds lies in a shallow basin, and is unconformable to the basalt and overlaps on it. After examining these beds at different places and collecting the fossils, the following succession was made out, although the thicknesses cannot be taken as absolute, the beds never being found in an escarpment of any height to allow of a careful measurement being made :—

[1] Loc. cit., pp. 54–5.
[2] Loc. cit., p. 53.
[3] Loc. cit., pp. 106–112.

		metres.
Top.	Purplish, hard, gritty limestone	5
2.	Yellow gritty beds	5
3.	Porous limestone with few grits containing pieces of *Echinolampas* sp., *Pecten* sp., casts of *Lucina ornata*, Ag., and *Cytherea pedemontana*, Brn.	10·4
4.	Gritty limestone	13
5.	Hard, dark, calcareous grit containing *Pecten Kochi*, Loc., *Lucina ornata*, Ag., *Cardium Michelottii*, Desh., *C. multicostatum*, Brocc., *Venus islandicoides*, Lam., *Venus* sp., *Tapes vetula*, Bast., *Tellina planata*, Lam., *Mactra corallina*, Lam., *Corbula revoluta*, Bast., *Turritella miotaurina*, Sacc., *Turritella* sp. ...	2
6.	Yellow calcareous sand and grit containing *Ostrea* sp., *Pectunculus* sp., *Chama* sp., *Cardita* cf. *pinnula*, Bast., *Cardita* sp., *Lucina columbella*, Lam., *Lucina* (*Dentilucina*) sp., *Lucina* sp. (many), *Cardium paucicostatum*, Sow., *C.* cf. *paucicostatum*, Sow., *C. multicostatum*, Brocc., *Cardium*, sp. nov., *Cardium* sp., *Venus multilamellata*, Lam., *Cytherea pedemontana*, Brocc., *C. erycina*, Lam., *Tapes Basteroti*, May., *T. vetula*, Bast., *Tellina lacunosa*, Chemn., *Tellina planata*, Lam., *T. nitida*, Pol., *Tellina* sp., *Mactra corallina*, Lam. = (*M. stultorum*, Lam.), *Corbula revoluta*, Brocc., *Calyptræa chinensis*, Lam., *Turritella miotaurina*, Sacc., *T. terebralis*, Lam., *Ficula condita*, Brongn., *Oliva* sp., *Scaphander* sp.	11
7.	Calcareous grits with limestone at the base containing *Cytherea* sp., *Tellina* sp.	7
8.	Grits and siliceous limestone containing *Lucina* sp., *Cardium* sp., (?) *Tapes* sp.	6
9.	Yellow siliceous grit containing small *Cardia*	5
10.	Hard, black, calcareous sandstone	1·8
11.	Yellow sandstones and grits	13

Lower Miocene.

Basalt underlies this last bed.

The beds have a general dip of 3° to 5° N.E., but there is also a gentle inclination of about 2° to the north-west.

Further east the following fossils were obtained from the representative of Bed 7 of the above section :—*Ostrea* sp., *Cardita* sp., *Lucina columbella*, Lam., *Lucina* sp., *Cardium* sp., *Tapes vetula*, Bast., *Tapes* sp., *Mactra* sp., *Corbula Basteroti*, Hörn., *Corbula* sp., *Cancellaria* sp.

Round about Station 4 of the Old Post Road to Suez, a calcareous grit yielded the following fossils :—*Pinna* sp., *Ostrea* sp., *Modiola* sp., *Pectunculus* sp., *Cardita* sp., *Lucina columbella*, Lam., *L. ornata*, Ag., *L.* sp. nov., *Lucina* sp., *Cardium* sp., *Venus ovata*, Penn., *V.* cf. *islandicoides* L., *Cytherea erycina*, Lam., *Tapes* sp., *Tellina lacunosa*, Chemn., *T. nitida*, Pol., *T. planata*, L., *Calyptræa chinensis*, Lam., *Turritella terebralis*, Lam., *Strombus* sp., (?) *Panopæa* sp.

At the north foot of Gebel el Angobia in calcareous grits and marls, *Dosinia Adansoni*, Phil., is found associated with *Tapes vetula*, Bast., *Lucina ornata*, Ag., *Cardium multicostatum*, Brocc., *Turritella terebralis*, Lam., *T. cathedralis*, Brongn., *Conus* sp., and *Pleurotoma trochlearis*, Hörn.

At the base of Gebel Rieshi, 12 kilometres north-east of Bir Gendali, there is practically the same assemblage of fossils as in the previous case. Below these beds comes a series of conglomerates, gravels, sands, etc., lying between Gebel el Angobia and Amuna.

These overlie the basalt, and are seen to pass under the fossiliferous beds of the Miocene.

At the Middle Station, Old Railway to Suez, some gypseous marls and brown ferruginous limestones are brought up by a fault and exposed in a cutting. These contain the following fossils:—*Pecten* sp., *Cardita* sp., *Arca* cf. *Fichtelli*, Desh., *Cardium multicostatum*, Brocc., *Cardium* sp., *Dosinia Adansoni*, Phil., *Venus ovata*, Penn. (numerous), *V. multilamellata*, Lam., *V.* cf. *plicata*, Gmel., *Venus* sp., *Cytherea erycina*, Lam., *Trochus tauro-miocænicus*, Sacc., *Turbo tauro-miocenicus*, Sacc., *Turritella terebralis*, Lam., *Ficula* sp., *Triton* sp., *Scaphander lignarius*, Lam., *Scaphander* sp.

At the foot of the Miocene escarpment to the south-west of Gebel Gafeisad or Agleiat Qamr, Lower Miocene fossils were also found in some sandy beds, while pieces of mammalian bones in a bad state of preservation were also seen.

From the base of the Miocene cliff 15 kilometres east of Dêr el Bêda the following fossils were obtained:—*Scutella Deflersi*, Gauth., *Scutella* sp., *Brissopsis*, sp. nov., *Pecten Kochi*, Loc., *P. Schweinfurthi*, Blanck., *P. Ziziniæ*, Blanck., *P. submalvinæ*, Blanck., *P. burdigalensis*, Lam., *Pecten* sp., *Pectunculus* sp., *Cardita* sp., *Cardium paucicostatum*, Sow., *C. multicostatum*, Brocc., *Cardium* sp., *Dosinia orbicularis*, Ag., (?) *Venus* sp., *Cytherea* sp., *Tapes vetula*, Bast., *Corbula revoluta*, Brocc., *Turritella* sp., *Ficula condita*, Brongn. Here there is undoubtedly a mingling of Helvetian and Lower Miocene fossils which marks what may be regarded as the passage-bed between these two stages of the Miocene.

At the foot of Gebel Genêffe a series of unfossiliferous beds (brown sandy limestones, gypseous clays, gypsumized limestone, and greenish marls) occur; they form a part of the Lower Miocene, as is shown by correlating the overlying fossiliferous beds with those in other sections in which these latter are found always to overlie the Lower Miocene beds.

In this district there is abundant proof to show that there was a great overlap of the Miocene beds from west to east. Near Cairo they lie on a thin layer of basalt which is a good distance from any of the known volcanic necks; further east in the immediate neighbourhood of the vents no basalt is found under the Miocene rocks except in very small patches, while the Oligocene sands and gravels are much thinner. This, to the writer's mind, is best explained by a gradual overlap from west to east. If it were otherwise, the basalt ought to be thickest in the neighbourhood of the volcanic vents, while west and east from them it would gradually thin out and disappear. The converse is the case, as the main basalt flow on the west side is remote from the volcano, while only on the flanks of the cone is it found close to the vent, and on the east it is entirely absent. The earlier submergence of the area near Cairo has protected the basalt from being totally swept away, as was the case with the longer exposed area to the east.

It would seem also as if deeper water existed to the east in Helvetian times, while the white limestone found there in such

thickness was probably never deposited in the neighbourhood of Cairo. It is a fact that, as the Miocene is traced eastward, the beds thicken and become almost pure limestone, while others that were sandstone on the west have passed over into limestone further east.

REVIEWS.

I.—Photographs of Geological Interest in the United Kingdom.[1]

(PLATE XVIII.)

IT is again our pleasant task to call the attention of the readers of the Geological Magazine to the excellent work performed by Professor W. W. Watts, F.R.S., and his Committee for recording and preserving photographs of places and sections of geological interest in the United Kingdom. The report from which most of the following statements are taken shows that the past year has been exceptionally successful, the number of new photographs received having exceeded that of any previous year. The accessions number 543; the total number in the collection is 4,314, and the yearly average rises to 287. Since issuing the report 100 other photographs have been received.

The geographical scheme annexed shows that four counties are removed from last year's 'black list'—Cambridge, Kildare, Leitrim, and Wicklow having now made contributions to the collection. There are still 21 non-contributing counties—two in England, one in Wales, seven in Scotland, and eleven in Ireland.

To this year's list Yorkshire makes, as so often before, the largest contribution, 243; Norfolk follows with 43, Kent with 31, and Pembroke with 30. Considerable additions are made to the lists of Buckingham, Northampton, Suffolk, Fife, Linlithgow, Renfrew, Cork, and Sligo.

	Previous Collection.	Additions (1904).	Total.
England	2,308	415	2,723
Wales	250	41	291
Channel Islands	38	—	38
Isle of Man...	60	1	61
Scotland	422	37	459
Ireland	597	49	646
Rock Structures, etc. ...	96	—	96
Total	3,771	543	4,314

[1] Fifteenth Report of the Committee, consisting of Professor James Geikie (Chairman), Professor W. W. Watts (Secretary), Professor T. G. Bonney, Professor E. J. Garwood, Professor S. H. Reynolds, Dr. Tempest Anderson, Dr. J. J. H. Teall, Mr. Godfrey Bingley, Mr. H. Coates, Mr. C. V. Crook, Mr. J. G. Goodchild, Mr. William Gray, Mr. W. Jerome Harrison, Mr. Robert Kidston, Mr. J. St. J. Phillips, Mr. A. S. Reid, Mr. R. Welch, Mr. W. Whitaker, and Mr. H. B. Woodward. (Drawn up by the Secretary, Professor W. W. Watts, M.A., F.R.S., Sec. Geol. Soc.) Read before the British Association, Cambridge, Section C (Geology), August, 1904.

"London Bridge," a natural arch in Middle Devonian Limestone, Torquay.

From a photograph by Professor S. H. Reynolds, M.A., F.G.S. (See p. 613.)

It is not easy to pick out any particular series of photographs for special mention, but a set of seventeen prints from Mr. Charles C. Buckingham and two from Mr. De Vere, all taken under the auspices of the East Kent Natural History Society, seem to be of exceptional interest. They illustrate the course and tributaries of the Kentish river Stour, and their association with the springs known as Bournes. Mr. Buckingham has also photographed Reculvers Church from the same points of view as Lyell's famous pictures, and the result brings home the potency of marine denudation and the need for coast defences.

Mr. R. Vowell Sherring, working in conjunction with the Bournemouth and District Society of Natural Science, sends some beautiful prints of the Bournemouth cliffs; Mr. Mellard Reade contributes some excellent photographs of the well-known gypsum boulder of Crosby; and Mr. Topham a series from the gravels of Eye in Northamptonshire. The rhythmical fretting of limestone by water in Hell Gill is illustrated by Mr. Rodwell under circumstances of considerable difficulty, and the marine destruction of the Scarborough landslips by Mr. Monckton. Mr. Leach sends photographs of a mass of Carboniferous Limestone at Tenby, supposed to show 10,000 specimens of *Productus*, and, curiously enough, almost the same post brought a notice that "the Corporation have for years been breaking up the stone for road repair, and are now in possession of a steam stone-breaker which will in the course of time cause this natural curiosity to disappear, unless some steps are taken to prevent it."

Messrs. Muff & Wright have taken an ideal set of photographs of the raised beaches and platforms of Cork, which are buried under boulder-clay, blown-sand, and 'head'; Mr. Pledge continues to illustrate Mr. Davies's work on the Purbeck and Portland of the Haddenham district; Mr. Robarts sends further contributions on the geology of Kent and Surrey from the Croydon Natural History and Scientific Society; and Mr. Plews gives the first photographs recorded from Cambridgeshire.

The importance of the contributions of members of the Committee will be realised from the fact that they are responsible for 426 photographs out of a total of 543. Mr. W. Jerome Harrison, one of the earliest and most earnest of geological photographers, and perhaps the pioneer of county photographic surveys, sends no less than 270 prints out of his large collection of a lifetime. These comprise a long series of the Yorkshire coast from Bridlington to Whitby; series from Cornwall, Norfolk, and Suffolk; and our first connected set from the Cambrian rocks of St. Davids. Mr. Bingley contributes 76 prints taken in Norfolk, Suffolk, Yorkshire, Anglesey, and Carnarvon. Professor Reynolds's work is well represented by illustrations from Hertfordshire, the Carboniferous area of Somerset, and volcanic areas in Fife, Haddington, and Linlithgow. Last, but not least, Mr. Welch makes a valuable gift of 35 prints taken in Lancashire and Ireland, in connexion with the work of the Belfast Naturalists' Field Club and of Mr. Praeger and Mr. Lamplugh.

They include examples from Antrim and Cork, the glacial and associated deposits of Down and Dublin, and phenomena connected with limestones and caves in Sligo. One of the photographs is both botanical and geological, for it shows the formation of tufa in a limestone district through the agency of colonies of various mosses.

To all the gentlemen named the Committee tender their best thanks, as well as to the following, who have contributed less in amount, it is true, but individual examples or series of high value: Mr. Epps, Mr. G. T. Atchison, Mr. Hopkinson, Messrs. Abley & Griffith, Mr. Hodson, Professor Armstrong, Mr. Cobbold, Dr. Matley, Dr. Flett, Dr. Abbott, and Mr. Smith.

Mr. Welch points out that one print registered last year (3,289), the cemented breccia of quartzite and slate at Howth, which contained bones of mammals and fishes with land and marine shells, is now the only record of an interesting geological fact, as the block has been washed away by the sea.

The third and last issue of the published series of "British Geological Photographs" was sent out to subscribers in May of this year. The completion and success of its first publication scheme marks an epoch in the history of the Committee and the fulfilment of a long-cherished desire of its founders.

Since the first meeting in 1890 the desirability of publishing a selected series of geological photographs has been kept before the Committee, but it was only in 1893 and 1894 that publishers were approached on the subject. With one consent they recommended application elsewhere, and so the matter was allowed to slumber till the Dover meeting in 1899. In this year a Sub-Committee of selection, consisting of Professor Bonney (Chairman), Professor Watts (Secretary and Editor), Professor Garwood, Dr. Mill, Dr. Teall, and Mr. H. B. Woodward, was appointed, a self-supporting subscription scheme drawn up, and a preliminary selection of typical photographs made. One hundred and ninety-three subscribers undertook to support a series which was to consist of issues of twenty photographs each year for three years. It was decided to issue the series in three forms—unmounted half-plate platinotypes, mounted platinotypes, and lantern-slides—and each issue was to be accompanied by descriptive letterpress.

Various unforeseen circumstances delayed the first issue, but it saw the light in September, 1902; issue ii followed in July, 1903; and the final issue in May, 1904. The actual series, as published, comprised seventy-two photographs, fifty-one being standard half-plates, ten quarter-plates, and eleven whole-plates, and an equal number of lantern-slides. The subjects ranged over most of the ordinary geological phenomena, the chief rock formations, and many of the more important British localities. The negatives were lent by thirty-four photographers, and a descriptive pamphlet of forty-two pages was written by thirty-four contributors, amongst whom are many of the most famous of contemporary British geologists. To both geologists and photographers the Committee express their warmest thanks.

The estimates on which the Sub-Committee worked proved to have been well founded, and the balance-sheet gives an account of all receipts and expenditure to date. It shows a balance in favour of the Committee of £95 13*s.* 2*d.*, and a prospective profit of over £130 when all outstanding accounts shall have been paid.

The balance-sheet, however, does not make one important point clear. Eight whole-plate platinotypes and twelve slides beyond the number agreed upon have been issued to subscribers. It is estimated that these additional photographs have cost £105. If this be added to the balance in hand the total profit has been £235, of which one-half has been returned to the subscribers and the other half retained by the Committee for the purpose of carrying on the work for which it was originally established by the Association.

It was pointed out in the Report for last year that in its fifteen years' work of collecting and storing photographs, the Committee had spent £101 10*s.* of the £130 granted to it by the Association. In making a clear profit of £130 the Committee may congratulate itself on having "earned its keep," and perhaps it is the only Committee of the Association which has ever succeeded in literally doing so. But, besides this, by scattering broadcast over the world typical photographs of geological features and phenomena it has rendered a service to geological, and perhaps to geographical, teaching which cannot be well over-estimated. The British Association photographs are forming the nucleus of dozens of teaching collections in the universities, schools, and museums of Britain; and numerous foreign subscribers write that they are only unable to subscribe to a second series because they now want the funds to accumulate other examples from their own countries. It is not so difficult to obtain geological photographs as it was fifteen years ago, for even the ubiquitous picture postcard is sometimes frankly geological.

About 100 intending subscribers to a new series have sent in their names, and the Committee recommend that such a new series be undertaken on the same terms as the last. With the smaller number of subscribers, however, the margin is narrow, and while profit to the Committee will be small, or absent, the subscribers will have to be content with the "contract number" of photographs. Possibly the number of subscribers will increase when it is known that the new series will be actually carried out.

Such a series will naturally be complete in itself, but it will also be supplementary to the first series, and in no way a repetition of it. The Committee would most warmly welcome any suggestions from subscribers and others as to the best points to be considered in the new series.

Examples of the published series of photographs were shown at the Exhibition arranged by the Geographical Association in London and the provinces this year. Another set was sent by request to the Exhibition at St. Louis, and it is proposed to present this collection to the Geographical and Geological Department at Harvard University when the Exhibition closes. To this set a gold medal in Group 16 has been awarded.

The duplicate collection of slides has been exhibited and explained within the year by Mr. Whitaker at the following local scientific societies:—The Christ's Hospital Natural History Society; the Greville Place Literary Society, Maida Vale; the Stratford Congregational Literary Society; and the Ashmolean Natural History Society, Oxford.

Applications by Local Societies for the loan of the duplicate collection should be made to the Secretary. Either prints or slides, or both, can be lent, with a descriptive account of the slides. The carriage and the making good of any damage to slides or prints are expenses borne by the borrowing society.

The Committee recommend that they be reappointed, without a grant.

Fifteenth List of Geological Photographs.

(*To August* 12, 1904.)

This list includes the geological photographs which have been received by the Secretary of the Committee since the publication of the last report. Photographers are asked to affix the registered numbers to their negatives for convenience of future reference. Their own numbers are added in order to enable them to do so.

Copies of photographs desired can, in most instances, be obtained from the photographer direct, or from the officers of the local society under whose auspices the views were taken.

The Committee *do not assume the copyright of any photographs* included in this list. Inquiries respecting photographs, and applications for permission to reproduce them should be addressed to the photographers direct.

It is recommended that, wherever the negative is suitable, the print be made by the cold-bath platinotype process.

The very best photographs lose half their utility, and all their value as documentary evidence, unless accurately described; and the Secretary would be grateful if, whenever possible, such explanatory details as can be given were written on the forms supplied by him for the purpose, and *not on the back of the photograph or elsewhere*. Much labour and error of transcription would thereby be saved. It is well, also, to use a permanent ink for this purpose. A local number, by which the print and negative can be recognised, should be written on the back of the photograph and on the top right-hand corner of the form.

Copies of photographs should be sent *unmounted* to Professor W. W. Watts, F.R.S., The University, Birmingham, and forms may be obtained from him.

Our Plate XVIII this month is taken from one of the series of Photographs of Geological Interest issued by the British Association Committee, and represents an excellent view of "London Bridge," a natural arch at Torquay, Devonshire (No. 2,938 of the series). Photographed and reproduced by permission of Professor S. H. Reynolds, M.A., F.G.S. The following description by Mr. W. A. E.

Ussher, F.G.S., and the block annexed, are taken by permission from the letterpress issued with the last set of the first published series of "British Geological Photographs":—"The natural arch depicted in the photograph forms a conspicuous object on the south coast of the Torquay Promontory between the Bath Saloons and Daddy Hole. It has been tunnelled by the sea through a small headland near the axis of an inverted synclinal curve in Middle Devonian Limestones. The prolongation of this axis eastward is well shown on the coast a quarter of a mile away. In the middle and lower part of the limestone masses of Torquay, a partial cleavage is often displayed by the beds, consequent on the pressure

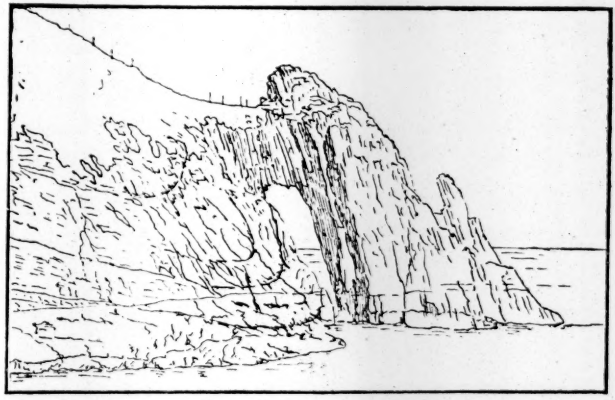

Diagram figure of Natural Arch, Torquay; drawn to show inverted Syncline.

which has produced the folding in them; this structure, as shown in the photograph, becomes in certain cases most pronounced at and near the axis of the folds, causing a shattering of the rock at the point where the direction of strain cleavage approximates to, or coincides with, the inverted bedding planes. The dark marking extending horizontally on either side of the arch in the photograph denotes high-water mark. The railings give a scale. This locality, from a slightly different point of view, has been figured in the Memoir on the Geology of the Country around Torquay, p. 49 (Mem. Geol. Surv., 1903), in which the Middle Devonian Limestones of that district are also described."

II.—On some important occurrences of Granular Carbonate Rocks, with special reference to their Origin and Structure. By Bernhard Lindemann. Neues Jahrbuch f. Min. Geol. u. Palæont. XIX Beilage Band (1904), Heft 2.

THIS important paper on crystalline limestones and dolomites contains about 9 pages of bibliography, 5 or 6 pages of review of older theories of crystalline carbonate rocks, nearly 100 pages of descriptions of special occurrences, and 10 pages of discussion of

the general character and origin of the rocks and of their accessory minerals. The second and last sections are briefly reviewed here.

Cotta held in 1827 that crystalline limestones might be either (1) original secretions of calcium carbonate from the fiery fluid planet mass, like the plutonic crystalline schists; (2) rocks independently erupted from the earth's interior; (3) altered compact (sedimentary) limestones.

The second or truly eruptive limestones were characterised by their numerous inclusions of fragments of baked schist (or gneiss) [such as are common in the crystalline limestones of Ceylon—however they got there]; and by their wonderful close and intimate relation to the schists or gneisses they are associated with. Later on, in 1853, he abandoned the eruptive view and thought that such limestones had been more softened by heat than the surrounding rocks, and had thus been able to *behave* as eruptive rocks, and force their way under the influence of pressure into the crevices of the surrounding rock and even to form dykes and bosses in them, and break across their foliation planes. Then followed a gradual consolidation to a granular crystalline rock, accompanied by the development of contact-metamorphic minerals. [This describes with wonderful exactness the sort of thing that seems to have happened in connection with the crystalline limestones of Ceylon, whatever their actual origin may have been.]

Naumann, too, believed that crystalline limestones might have consolidated from a state akin to fusion ("aus dem feurig erweichten Zustande"). The 'Neptunists,' on the other hand, thought that crystalline limestones resulted from the alteration of organic limestones by percolating waters which dissolved and redeposited the calcite, and introduced other carbonates and silicates as well; and they ignored the possibility of contact-metamorphism. These views seem to result from a confusion of the truly crystalline limestones of the schists with the ordinary crystallisation and obliteration of organic structure that has often taken place in sedimentary limestones.

At the present day a majority of geologists (Gümbel, Lepsius, Vogt, etc.) ascribe the characters of crystalline limestones to regional or dynamo-metamorphism; some others, to the contact-metamorphic effects of intrusive igneous rocks. In regional metamorphism four factors are involved, viz., (1) water as a solvent, (2) high temperature, (3) mechanical pressure, (4) long-extended time of action. [Certainly pressure alone appears to result in the degradation of already crystalline limestones, as in Iowa, and not in the *development* of a crystalline structure.]

Vogt has attempted to separate regional from contact-metamorphic crystalline limestones, on the ground of differences in mineral composition and of certain peculiarities of structure. He thinks that an interlocked or granulitic (*verzahnten*) structure is characteristic of regional metamorphic limestones, and that it is wanting in almost all that are of contact-metamorphic origin; and further, that, in consequence of this peculiarity, hardly any marbles save those

of regional metamorphic character are valuable for ornamental purposes.

The observations of the author of the paper under review show, however, that these distinctions cannot be maintained. Nor does he agree with Vogt in regarding certain minerals (garnet, vesuvianite, scapolite, wollastonite, pyroxene, amphibole, epidote, chondrodite, felspar, tourmaline, spinel, etc.) as characteristic of contact-metamorphic limestones, and others (quartz, actinolite, mica, talc, chlorite, rutile, hematite) as occurring in limestone of regional metamorphic origin. According to our author, however, the accessory minerals *do* fall into two groups, the first, including garnet, wollastonite, vesuvianite, diopside, periclase, and spinel, being characteristic of limestones altered by *normal* contact-metamorphism, and the second, including quartz in rounded grains, and members of the mica, chlorite, amphibole, and epidote groups, and also corundum, occurring in limestones altered by *piezo*-contact-metamorphism (contact-metamorphism accompanied by pressure); here the carbon dioxide being unable to escape, the formation of wollastonite is impossible, and denser minerals are formed in place of lighter ones, corundum e.g. replacing spinel. On the other hand, phlogopite, forsterite, epidote, and pyrrhotite occur with either group of contact-metamorphosed limestones. [This classification does not *exactly* apply in Ceylon, where, in spite of the absence of wollastonite, spinel is not replaced by corundum.] All the minerals so far mentioned result from the alteration of matter present in the original limestone; magnetite and ilmenite are also primary minerals.

Other minerals—tourmaline, scapolite, apatite, fluor, topaz, and some mica—are probably of pneumatolytic origin, and derived from the intrusive magma; and so with pyrites, hematite, and sphene. Some lime-bearing silicates—particularly garnet, wollastonite, diopside, actinolite, etc., when they occur in concretionary nodules and layers near to the intrusive rock—may also be of external origin, and not merely developed from materials originally present in the limestone.

The author considers that the granular limestones and dolomites are without exception of organic origin, and that—at any rate in the vast majority of cases—their mineral composition and crystalline structure are the results of contact-metamorphism. The paper ends with a list of the accessory minerals that occur in crystalline limestones and dolomites. A. K. C.

III.—Catalogue of the Mesozoic Plants in the Department of Geology, British Museum (Nat. Hist.). The Jurassic Flora, II: Liassic and Oolitic Floras of England (excluding the Inferior Oolite Plants of the Yorkshire Coast). By A. C. Seward. pp. 192, pls. xiii, text-figs. 20. 1904.

THIS volume constitutes the Second Part of the Catalogue of Mesozoic Plants in the British Museum. The First Part, published in 1900 by the same author, dealt with the magnificent collection from the Inferior Oolite of Yorkshire. The present

volume gives a full account of the other English plants from the Trias, Rhætic, and Jurassic. With the exception of those from the Stonesfield Slate of Oxfordshire and the Lias of Dorset, plant remains are not at all abundant in any of these formations, and such as occur are often fragmentary or ill-preserved. Thus, while a number of the specimens dealt with in this volume have proved unsatisfactory as records of the plant life of the period, their elucidation, as far as it has proved possible, has added considerably to what was previously known on this subject, and is therefore highly valuable.

After a brief discussion of the present state of our knowledge of the earliest Mesozoic floras in various parts of the world, the author passes on to describe in detail the few fragments of Triassic and Rhætic age in the collection. The former period is represented by only one plant remain, a seed known as *Carpolithes* sp. From the Rhætic, fragmentary specimens are referred to *Equisetites Muensteri* (a typical species of the period), *Lycopodites lanceolatus*, and a fern *Clathropteris platyphylla*.

The Lias plants are represented by several specimens of the following species among others :—*Thinnfeldia rhomboidalis*, *Cycadites rectangularis*, *Otozamites obtusus*, and *Pagiophyllum peregrinum*. Many of these are well-preserved and fairly perfect specimens. A new species of fossil wood is described as *Cupressinoxylon Barberi*.

A special section is devoted to a discussion on the nature and origin of Jet. It is shown that in all probability Whitby jet has been produced in large measure by the alteration of wood of the Araucarian type.

The collection from the Stonesfield Slate (Great Oolite) is the largest described in this volume. It includes examples of *Ginkgo digitata* and *Baiera Phillipsi* ; several Cycadean fronds such as *Williamsonia pecten*, *Zamites megaphyllus*, as well as two new species. *Sphenozamites Belli* and *Podozamites stonesfieldensis*. Coniferous remains, especially *Thuites expansus*, are also fairly abundant.

Perhaps the most interesting specimen botanically is a leaf described as *Phyllites* sp., which in several respects closely resembles that of a recent Dicotyledon. The author remarks that "had the specimen been found in rocks known to contain the remains of Angiosperms, there would be no hesitation in identifying it as a leaf of a Dicotyledon ; but seeing that we know of no undoubted Angiospermous fossil in Jurassic strata, it is of the utmost importance to demand satisfactory evidence before identifying a plant, or fragment of a plant, as an Angiosperm."

The remains from the Oxfordian, Corallian, and Kimeridgian are few in number, and consist for the most part of Coniferous twigs or cones.

The memoir concludes with tables of the geographic distribution of the species described, and a short discussion on the botanical features of these floras. A full bibliography is appended.

REPORTS AND PROCEEDINGS.

Geological Society of London.

The opening meeting of the session 1904–5 took place on November 9th.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Mr. E. T. Newton, in exhibiting, by permission of the Director of H.M. Geological Survey, a specimen of *Fayolia* near to *Fayolia grandis*, found by Dr. L. Moysey, of Nottingham, in the Coal-measures of Ilkeston (Derbyshire), pointed out that *Fayolia* was first described by Professors Renault & Zeiller in 1884, in their monograph on the "Houiller de Commentry." In 1894 Mr. Seward described the first British specimen, from Northumberland, in the Leeds *Naturalist*, but thought that it was not a plant. There was some resemblance to certain spiral egg-cases of Elasmobranchs; but Dr. Günther was unwilling to accept the Northumberland fossil as the egg-case of a fish. Mr. Kidston had not yet seen the specimen now exhibited; but, from a sketch, he recognised its relation to *Fayolia*. At present, there was still uncertainty as to the exact nature of this fossil.

The following communications were read:—

1. "Notes on Upper Jurassic Ammonites, with special reference to Specimens in the University Museum, Oxford: II.[1]" By Miss Maud Healey. (Communicated by Professor W. J. Sollas, Sc.D., LL.D., F.R.S.) This was the first occasion in the history of the Geological Society when a lady, the author of a paper, was not only present, but read her own paper and replied to the discussion thereon.

This paper gives a redescription of the types of *Cardioceras vertebrale*, Sow., *C. scarbrugense*, Y. & B., *C. cordatum*, Sow., and *C. excavatum*, Sow., and their varieties. Four varieties of the first, nine of the second, three of the third and fourth, are defined, and a description is given of a new species of *Cardioceras* belonging to the same group. Notes on species allied to the group and on others which have been wrongly confused with it are added. These species are so closely connected by innumerable transitional forms that their limits cannot be definitely fixed. The term 'species' is therefore used as equivalent to Professor J. W. Gregory's *circulus*: "It includes a number of 'forms,' which vary along lines radiating outward from a central type. Some of the members farthest removed from the centre may be within the range of another *circulus*, for the different *circuli* may overlap or be connected by an indefinite series of individuals." Each *circulus* is made up of *subcirculi* or varieties, and several *circuli* make up a group which need not necessarily correspond with a genus. *C. cordatum* is retained as the name of the whole group, although the type is a most unsatisfactory little specimen from the Corallian of Shotover.

[1] For Part I see Geol. Mag., 1904, p. 39.

2. "Sarsen-Stones in a Clay-Pit." By the Rev. E. C. Spicer, M.A., F.G.S.

Near to Bradenham, midway between High Wycombe and Prince's Risborough, certain clay-pits yield a clay for brick-making, in which are embedded large angular sarsen-stones, white saccharoidal sandstones with a siliceous cement. This clay is quite flintless: it rests upon, and is 'contained' by, Clay-with-Flints based upon Chalk, and is covered with roughly-mingled material containing horizontal bands with worn flint-pebbles and drifted sarsens of smaller size. Each patch of the clay fits roughly into a funnel-shaped depression lined with Clay-with-Flints. The depressions are probably swallow-holes, formed by underground solution of the Chalk, which was covered by wet clay and that by sands of the Bagshot Series. As the clay oozed out into the hollows the sarsens of these sands broke away, and became involved in the clay, much as blocks of the Malmstone at Atherfield become involved in the mud-glaciers which descend from the underlying Gault in the sea-cliffs. The overlying formation is due to much later, and probably Pleistocene, action after the flints of the Upper Chalk had been exposed by denudation.

3. "On the occurrence of *Elephas meridionalis* at Dewlish (Dorset). Second communication: Human agency suggested." By the Rev. Osmond Fisher, M.A., F.G.S.

This paper is in continuation of one published by the author in 1888. The site in which the elephant-remains were found is a narrow trench, examined to a depth of 12 feet in places, with nearly vertical sides, a smooth, chalk bottom, and an abrupt end. It was not a fault or a stream-course, and it was partly filled with fine dust-like sand which may have been wind-borne. The trench cuts diagonally across the scarp; and, even if it could be accounted for by natural agencies, it is difficult to explain how it happened that so many elephants fell into it. The author points out that in Africa elephants are caught by the natives in pitfalls of similar character constructed on the tracts leading to watercourses. This trench is in a corresponding position with regard to a stream, and it is suggested as possible that the trench may have been of human origin. There is, however, no conclusive evidence elsewhere that man was contemporary with *Elephas meridionalis*, which is characteristic of the Pliocene Age.

Manchester Literary and Philosophical Society.

Folds in Rock Strata.—Professor W. Boyd Dawkins, F.R.S., dealt with a subject of much interest to waterworks engineers in a paper entitled "Notes on the effect of Relaxation of Pressure in causing Folds at the Bottom of Valleys" read by him before the Manchester Literary and Philosophical Society, of which he is President. It directed attention to a new cause of folding of the rock other than that which has been long recognized by geologists as ultimately due to the folding of the outer layers of the earth as they follow the contracting nucleus. The deep cuts made through

valleys to make watertight barriers in the construction of reservoirs revealed the fact that the bottom of the valleys, wherever it was formed of shales and thin sandstones, was more or less folded and contorted. These folds and contortions caused the shales to let the water through with more or less freedom, and he had been called in repeatedly to advise as to how far it was necessary to carry the puddle trenches down below the valley bottom. He found, as a matter of experience, that these folds were superficial, and if the sinking was made to a sufficient depth below the bottom of the valley they disappeared altogether. It was therefore obvious that they were not due to deep-seated movements of compression resulting from the contraction of the earth. They are due to the relaxation of pressure caused by the removal of the rock by denudation from the area of the valley, and are analogous in every particular to the 'creep' in coal workings, caused by the excavation of coal, by which the surrounding strata crush down into the area of relaxed pressure and ultimately fill it up. This may be studied in any coal-pit where there is a superincumbent pressure, say, of more than 1,000 feet.

Two illustrations of folding and faulting by relaxation of pressure are presented by the puddle trench of the Langsett reservoir belonging to the Sheffield Corporation, and by the two reservoirs now under construction on the head waters of the Derwent by the Derwent Water Board. In the first of these the foldings in question at the bottom of the valley in the shale under the first grit are strongly marked at the surface. These folds gradually disappear, and are based upon a hard black unmoved shale offering a good foundation about 60 feet below the bottom of the valley. This is in the valley of the Little Don. The thickness of rock removed from the bottom of the valley amounted to no less than something like 8,000 feet of Coal-measures and Millstone Grit. In the case of the Derwent, in which the folding is much more marked and is accompanied by faulting, the thickness of rock removed amounted to at least 9,700 feet (7,200 feet of Coal-measures, 2,000 feet of Millstone Grit, and at least 500 feet of Yoredale). In this the movement had not extended beyond a depth of 90 feet. In the case of the Derwent reservoir lower down the river there are two systems of folding and faulting which do not penetrate beyond 60 feet from the surface. At that point a good foundation is found for the puddle trench of the embankment. These points are of considerable importance in considering the sites for reservoirs.—From *Water*, November 15th, 1904, No. 71, p. 491.

CORRESPONDENCE.

THE NEW QUESTION OF RIPPLE-MARK.

Sir,—In the August number of the Geological Magazine I proposed to offer at some future time an explanatory paper on the formation of ripple-mark; writing then under the impression that experts were quite agreed upon a subject not generally known.

After my August paper was in type, Mrs. S. Ayrton expounded the subject of ripple-mark at the soirée of the Royal Society, and subsequently delivered a lecture at Cambridge under the auspices and special sanction of Section G.

In the course of the latter lecture Mrs. Ayrton ignored all previous enquirers, except Professor Darwin, whom she considered not to have fully appreciated the significance of his own experiments. This places me in a difficulty, as I am in doubt whether Mrs. Ayrton has considered the work of modern writers, or only the views expressed in the older text-books. Then there is another difficulty, and that is, that the subject was considered by Professor Osborne-Reynolds' Committee on Tides and Waves, which was a Section G committee; while the subject comes within the purview of the reappointed Committee on Terrestrial Waves, etc. As a matter of fact, Mrs. Ayrton's views, as endorsed by the Royal Society and Section G, are in conflict with the views accepted by two committees of the British Association and of all modern workers. Indeed, Mrs. Ayrton uses the words "Contrary to accepted opinion."

I am aware that Bacon declares that unanimity is a very dangerous thing, and that, theoretically, it might be safer for me to differ from Professors Darwin and Osborne-Reynolds, and Dr. Vaughan Cornish, who are the modern authorities who have dealt more particularly with the sand-ripples of tidal and other continuous currents; but, except in some microscopic points of details, there seems to me to be no room for doubt.

During the past months of September and October I had the little Moorland stream, the river Bovey, under close observation, and for eight weeks one particular sand-flat was more or less rippled.

Mrs. Ayrton maintains that a steady current cannot produce sand-ripples, and suggests that certain sand-waves on the Goodwin Sands are caused by stationary sea-waves. So far as my observation goes, there are no stationary waves in the open sea; and it is an uncontrovertible fact that a steady current, as understood by geologists, viz., a current flowing to all outward appearances continuously in the same direction, can, under certain conditions of speed, depth, and composition of bottom, form sand-ripples, as pointed out by Dr. Sorby, F.R.S., in 1859.

The point that geologists want decided is whether the sand-ripples proved by Monsier Siau in the Indian Ocean, in a depth of over 100 fathoms, were produced by continuous currents or by wave-action. A good deal turns upon the answer. To me the balance of evidence seems to be in favour of wave-action, because, as a rule, deep currents do not disturb the bottom, but slide over the strata of water which are in contact with the bottom; but I come to that conclusion in face of the fact that under certain circumstances continuous currents have been proved to ripple a sandy bottom.

I should like to see a committee appointed, to consist of all the leading workers who have written upon the subject of current ripple-mark, and especially of those who have delivered popular

lectures. I think, for instance, that if Professors Darwin, Osborne-Reynolds, and Fleming, with Dr. Vaughan Cornish and Mrs. S. Ayrton, were to confer and compare experiences a unanimous report might easily be arrived at. Until something of the sort is done the exposition of the subject, as endorsed and supported by the Royal Society and the British Association in their corporate capacities, will either be accepted by the public or cause a great deal of perplexity. The question does not touch my own special work, as all seem agreed as to the ripple-making powers of reciprocal wave-currents.

A. R. Hunt.

November 7th, 1904.

ELEPHAS MERIDIONALIS AT DEWLISH.

Sir,—I regret that I was unable to be present at the meeting of the Geological Society on the 9th inst., when my paper on the Dewlish elephant trench was read, suggesting human agency. I crave your permission to reply to one or two criticisms as reported in the Abstracts of the Proceedings. It is there said that some 'eoliths' found there were exhibited by me. If what I *did* exhibit is referred to, they were merely shown as geological specimens from the drift of the gravel with which the trench had eventually become filled—not as 'eoliths.' I have seen some 'eoliths' which were collected at Dewlish, but in my opinion (whatever that may be worth) they do not strengthen my hypothesis that the trench is artificial.

Mr. Hudleston remarked that he understood that the remains of only one elephant had been found. There are in existence *nine* well-preserved molars in museums, four at Dorchester, two at Salisbury, two at Cambridge, and one at Manchester. I exhibited at Cambridge all these except the Salisbury specimens. Mr. Pleydell in his paper in the "Dorset Field Club," 1889, mentions seven molars, so that two of the above enumerated must have been omitted in his list. In this paper he gives a list of remains. He says that isolated plates of other molars were scattered in various parts of the deposit, and that in some places fragments of ivory were so numerous as to predominate over other materials. This I think disposes of Mr. Hudleston's objection that the remains of only one elephant had been found.

It is obvious that the trench was not wide enough to contain the carcase of an elephant. But if such a beast once got his fore legs into a narrow trench twelve feet deep, he must have been in the "helpless condition" that Sir Samuel Baker refers to, in which he might have been dispatched at leisure. It is not likely that primitive men would have expended more labour upon their pitfall than was absolutely necessary.

O. Fisher.

Harlton, Cambridge,
November 18th, 1904.

THE DISCOVERY OF *MARSUPITES* IN THE CHALK OF THE CROYDON AREA.

Sir,—With reference to Dr. Hinde's paper on "The Zone of *Marsupites* in the Chalk near Croydon," we should like to point out that though in general his observations corroborate ours, we found at least four specimens of *Marsupites* with nearly complete tests, one with brachial joints in position, and a block containing most of the test plates and associated brachial plates, which is now in the possession of Dr. Bather. We also found several specimens of *Echinocorus conicus* near the Pank's Hill Road end, and in another part *Janira quinquecostata*. We agree with him that "the dip of the Chalk from the summit towards the north is probably about the same as that of the general slope of the surface," and see no occasion for Mr. Dibley's theory of a fold in the chalk. He says that the upper part of the *Cor-anguinum* beds are exposed at Beddington. We have questioned him as to this, and he admits he should have written Carshalton, and says he meant the section we showed him a few months ago which we then thought was no higher than the *Cor-anguinum* zone. Recently we have found there, among other fossils, tests and brachial plates of *Uintacrinus*.

With all due respect to Dr. Hinde, we cannot help expressing our surprise that he did not consider it necessary to refer to us as the original discoverers of the *Marsupites* zone in Surrey. Mr. Dibley certainly mentions us in a somewhat casual way, but as Dr. Hinde's paper is page-headed "Discovery of *Marsupites*, etc.," few readers will be aware that we made the discovery, spent days and hours among the thrown out blocks, inspected the trenches and *tunnels*, and had prepared a paper for the Proceedings of the Geologists' Association. It was unfortunate that our paper was not first in the field, as we were, but as we are mentioned in the number of your journal which contains Dr. Hinde's article, we have the satisfaction of knowing that the credit, if any, will be equally divided between the discoverers and the eminent geologist who has given his valuable time to the production of such an interesting and scientific paper.

W. Wright.
B. C. Polkinghorne.

13, Devereux Road,
Wandsworth Common, S.W.
November 16th, 1904.

MISCELLANEOUS

The Palæontology of the Lower Coal-measures of Lancashire is very fully dealt with by Mr. H. Bolton in the Transactions of the Manchester Geological and Mining Society (vol. xxviii, part 14).

Erratum.—In Mr. Coomáraswámy's paper on the Balangoda Group, in the August number, p. 422, the figure was one-half natural size, and not $5\frac{1}{2}$ times as there stated.

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